The Engineer

LONDON, FRIDAY, DECEMBER 4, 1942.

SITUATIONS OPEN

S OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

DVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.
the benefit of applicants, the Proprietors pared to insert brief notices that vacancies ed, upon receipt of notifications from the isers. These notices (limited to one line) e free of charge, and co-operation is for.

IMPORTANT

rtisers in Situations Open Column d make themselves acquainted with rms of

TATUTORY RULES & ORDERS 1941 No. 2069

TRICTION ON ENGAGEMENT ORDER

NTED, COMPETENT MAN, to Take Charge of Labour or Employment Office of Engi- Factory employing approximately 750 in South-West England area. Applicants e fully conversant with Restriction of ment Order, Essential Works Order, and had extensive experience in all labour s pertaining to engagement, discharge, and procedure. Applicants should state age, tails of experience to date, salary required, hether free for engagement, together with of recent testimonials.—Address, 9030, ngineer Office. 9030 A

NTED, MANAGER ENGINEER, Age 30/35, for Government Work. Yorks, West Factory 200 hands. Particulars and required.—Address, 9036, The Engineer 9036 A

IST WANTED for Ideas and Visuals by ading technical advertising agency; to finish artwork an advantage.—ROW-ON-BROUGHTON, 24, Mosley Street, hester. 9049 A

TOR WANTED. Only "All-round" Engineers should apply. Journalistic ex- e in the Machinery, Tools, Engineering, Electrical Trade essential. Send curriculum and fullest particulars, stating qualifica- and salary required, &c.—Address, 9061, The neer Office. 9061 A

NAGER REQUIRED, with Good Expe- ience of Travelling Grate Stoker Design for -tube Boilers. Must have had practical ience in Combustion and Operating Con- ns.—Apply, stating salary required, to N THOMPSON WATER TUBE BOILERS, Wolverhampton. 9045 A

NAGER REQUIRED for Experimental and Development Department in Factory ed on the Manufacture of Heavy Internal bustion Engines. Minimum qualifications ble first-class technical and workshop educa- experience in Testing and Direction of rimental and Research Work on Diesel nes. Applicant must have the ability to rtake mechanical, vibrational, and thermal ations. Permanent and progressive post suitable applicant. Salary according to fications.—Address, 9034, The Engineer 9034 A

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ERSEAS EMPLOYMENT.—An ASSIST- ANT MECHANICAL ENGINEER is RE- IRED for the Tanganyika Government Rail- for one tour of 20-30 months, with possible ension. Salary, £600, rising to £720. Free ages and quarters. Candidates must hold an neering Degree or equivalent qualification; served a pupilage or full apprenticeship a British Railway, passing through all ons of the Locomotive Repair and Building s, including Drawing-office and Running ; and have had at least two years' subse- experience.—Written applications (no rviews), stating age, full particulars of lifications and experience, and name of pre- employers, should be sent to THE RETARY, Overseas Manpower Committee 411A), Ministry of Labour and National ce, Hanway House, Red Lion Square, don, W.C.1. 9016 A

GENTLY REQUIRED for a Large Engi- neering Works in the East Midlands, ged on work of high priority, an ASSISANT CHINE SHOP SUPERINTENDENT, to Take ge of a Night Shift of some 150 workers, d labour. The post is one which calls for tive ability as well as technical knowledge. ary will be commensurate with qualifications. dicants should give full particulars of age, training, together with dates and details subsequent career.—Address, 9054, The Engi- Office. 9054 A

The Engineer

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SITUATIONS OPEN

OVERSEAS EMPLOYMENT.—A SECOND ASSISTANT PORT ENGINEER (MECHANICAL) is REQUIRED for the Basrah Port Directorate, Iraq, for one year in the first instance. Salary I.D.65 per month, plus cost-of-living allowance of between I.D.44 and I.D.6 per month, according to dependants (I.D.1 equals £1). Free passages, free medical treatment while in Iraq. Appointment not pensionable, but there is a Provident Fund. Candidates should be qualified Marine Engineers with shore experience, including Power-house Operation; be competent to maintain the Electrical and Water Supplies of the Port of Basrah and to Supervise Repairs to Craft.—Written applications (no interviews), giving full particulars of age, training, experience, and name of present employers, should be sent to THE SECRETARY, Overseas Manpower Committee (Ref. 541), Ministry of Labour and National Service, Hanway House, Red Lion Square, London, W.C.1. 9055 A

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THE Post You are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

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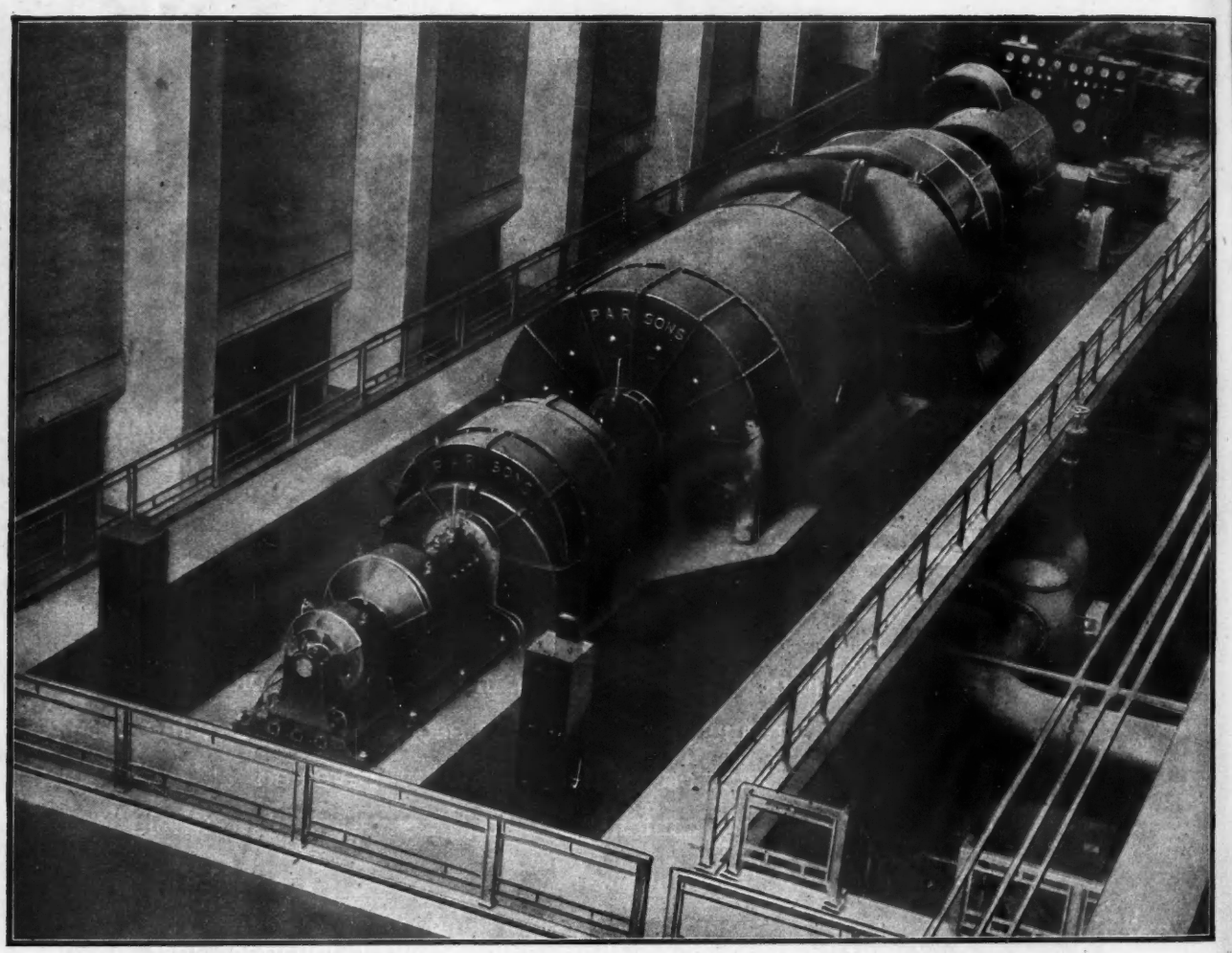

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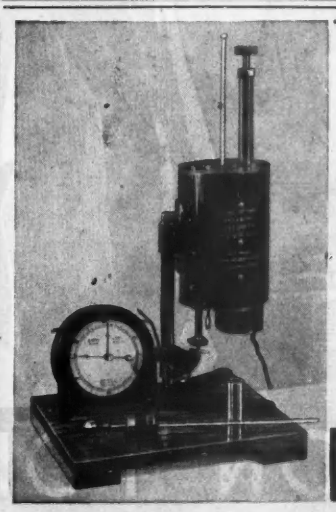

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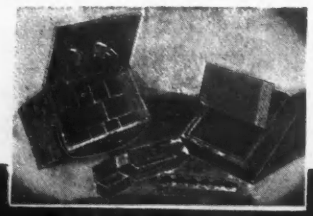

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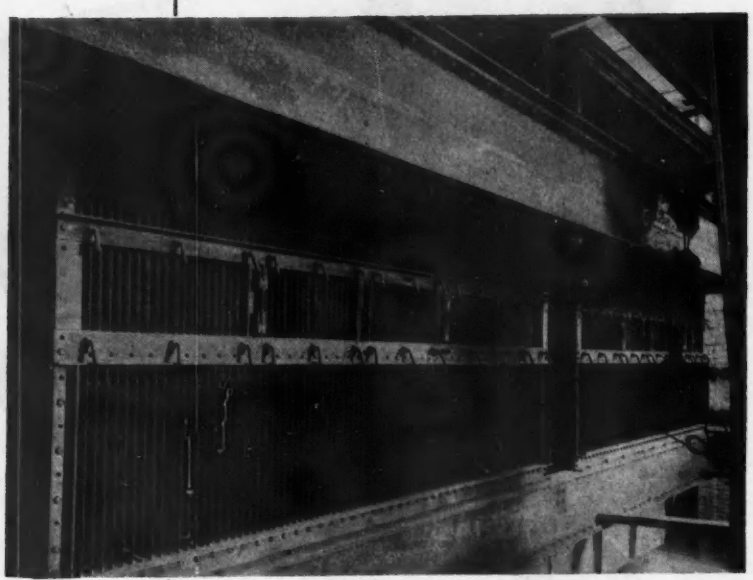

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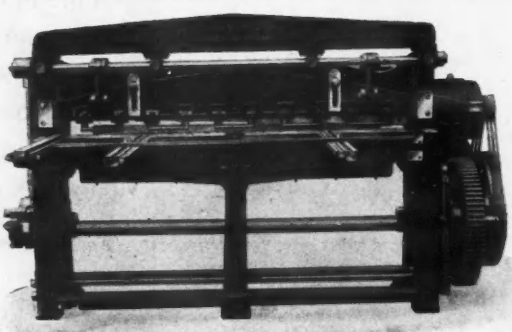

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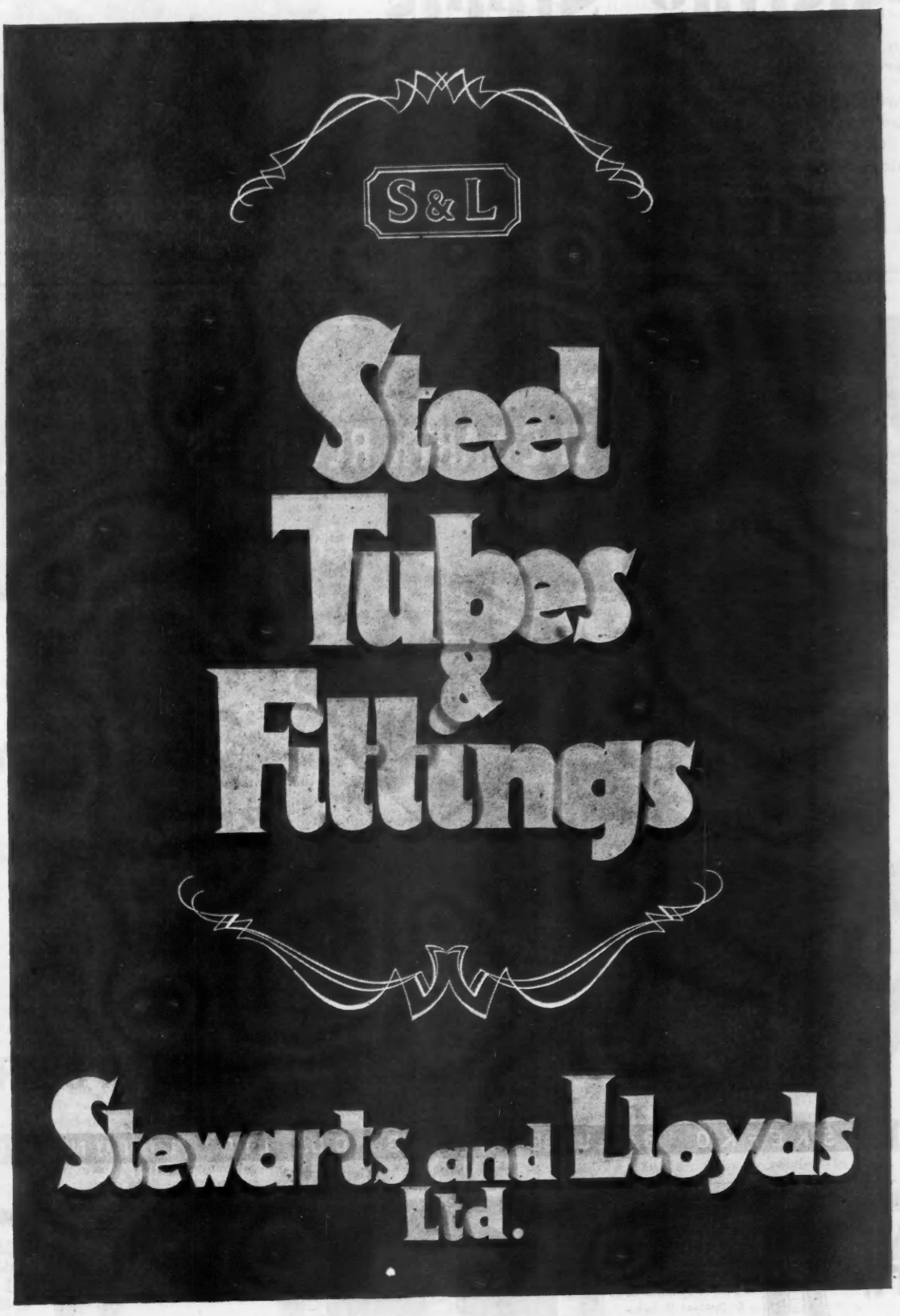
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The Scuttled French Fleet at Toulon

AT four o'clock on the morning of Friday, November 27th, German troops, on the orders of Hitler, entered Toulon, while German bombers dropped flares to illuminate the French warships, and other bombers dropped magnetic mines in the roadstead entrance. Bombs were also dropped on fortifications around the port. The troops made for the Milhaud docks, where the battleship "Strasbourg" was moored, and also the Vauban basin, in which the battleship "Dunkerque" was undergoing repairs. With the entry of the troops into the city, Admiral de Laborde gave the order to scuttle the ships, which was immediately carried out. All the captains stood on the bridges until their ships sank and most of them lost their lives. On some ships sailors opened fire on the German troops, and there were many casualities among the defenders of the ships and the crews engaged in the work of scuttling. It is believed that the following naval vessels were at Toulon:—The "Dunkerque" and "Strasbourg," both 26,500-ton battleships; the old 22,189-ton battleship "Provence"; the four 10,000-ton 8in.-gun heavy cruisers, the "Colbert," "Algérie," "Foch," and "Duquesne"; three light cruisers of 7500 tons, with 6in. guns, the "Jean de Vienne," "La Marseillaise," and "La Galissonnière"; the 10,000-ton seaplane carrier "Commandant Teste"; and about twenty-eight destroyers, of which about eighteen were of the large 2400-ton class; with about twenty submarines. All the ships were scuttled except four submarines, one of which is interned after reaching Barcelona and two others have, it is stated, reached Algiers and have been given a warm welcome by the French authorities. A further submarine called at Barcelona for refuelling and is believed to have left again for North Africa. Admiral de Laborde has been taken prisoner by the Germans and interned.

A Ministry of Planning

IN the debate on post-war reconstruction, which took place in the House of Commons on Tuesday, December 1st, it was stated that the Government had decided to ask Parliament to constitute a separate Ministry of Town and Country Planning in England and Wales. In making this announcement, Sir William Jowitt, the Minister responsible for co-ordinating post-war plans, gave what he called a sketch of the post-war situation, emphasising that whatever we hoped to achieve was conditional upon complete and unqualified victory by the United Nations. After warning the House that the immediate post-war period must be one of some difficulty, Sir William expressed confidence that when the shortage of raw materials was over and peace production had been resumed, we should be ready to meet the many demands at home and abroad. In trade it would be essential to pursue an expansionist policy. Sir William referred to the fact that consultations were proceeding as to the best methods of helping countries which had suffered occupation. He also stated that demobilisation must be on the basis of discharge according to age and length of service. Training of those whose educational careers had been interrupted was under review. He proposed to discuss with industry and the Trades Union Congress problems relating to the post-war organisation of industry and export trade. Housing would require important consideration. The matter of some alteration in the utility services was being considered, as cheap power was essential to industry. Problems of water supply were also under review.

The Late Mr. Charles S. Lake

IT is with deep regret that we announce the death, last month, of Mr. Charles S. Lake, who was the technical editor of our esteemed contemporary, *The Railway Gazette*, for many years, and an experienced writer on all matters relating to the construction and operation of locomotives. Charles Sydney Lake was born in 1872, and was the son of the late Mr. Henry H. Lake, one of the principal partners of the firm of Haseltine, Lake and Co., chartered patent agents and consulting engineers. His father had charge of the patenting of the late Mr. F. W. Webbe's many locomotive developments, and the boy made an early acquaintance with him, but, contrary to expectation, he did not become a pupil at Crewe. After completing his technical education in Berlin, he was apprenticed to the late William Marriott, in the Melton Constable shops of the old Midland and Eastern Railways. After gaining a wide experience in different branches of mechanical engineering, he studied marine engineering, and went to sea as an engineer of the Clan Line. About 1901, at the suggestion of Mr. Webbe, Mr. Lake began to write about locomotives, and thus started a career of more than forty years as a technical journalist. He contributed to the pages of *The Railway Gazette*, *The Daily Telegraph*, *The Shipbuilding and Shipping Record*, and *The Model Engineer* on locomotive, motoring, and marine subjects. In 1913 he became a part-time technical member of the staff of *The Railway Gazette*, gaining shortly afterwards a position on the staff of *The Motor Cycle Trader*. At the beginning of 1917 he was appointed assistant technical editor of *The Railway Gazette*, and the following year was made a consulting editor of *The Power User* (now *The Power and Works Engineer*). When in 1919 the control of *The Railway Engineer* passed to *The Railway Gazette*, Mr. Lake was appointed technical editor of both these journals. In recent years some changes took place owing to the war, and early in 1942 Mr. Lake was given the position of associate editor, having then passed his seventieth birthday. He was a member of the Institution of Mechanical Engineers, a member of the Institution of Locomotive Engineers, and a Fellow of the Royal Society of Arts. He was the author of several books, among which we may mention "The World's Locomotives," and "The Locomotive Simply Explained." His death will be mourned by a very wide circle of locomotive men, both in this country and abroad.

New Railway Appointments

IT is announced by the London and North-Eastern Railway Company that Mr. J. C. L. Train, M. Inst. C.E., the engineer of the Southern Area, has been appointed by the directors the chief engineer of the company, and will be responsible for the civil engineering of the whole system. It is also stated that further changes in the organisation of the company's engineering work will be reported at a later date. Another announcement by the directors of the London Midland and Scottish Railway Company is that Lieut.-Colonel Harold Rudgard, R.E. (Ret.), M.I. Loco. E., A.M.I. Mech. E., M. Inst. T., has been appointed to be superintendent of motive power of the London Midland and Scottish Railway. We may recall that Lieut.-Colonel Rudgard was a pupil of the late Samuel Waite Johnson, the locomotive superintendent of the old Midland Railway. The position he held before being appointed superintendent of motive power was divisional superintendent of operation (Midland Division) of the railway at Derby, which he occupied for over five years. Since the beginning of the war Colonel Rudgard has been acting with Mr. J. E. Kitching, the mineral manager of the London and North-Eastern Railway Company, as liaison officer with the Midland (Amalgamated) District Coal Mines Scheme, and jointly these two officers have developed a very careful system of block coal train working, which has been of considerable benefit to the M. (A) D., the railway companies, and the consumers. During the last war Colonel Rudgard was a Territorial, and after serving in the infantry for twenty months in France and Belgium he joined the Royal Engineers. During the latter part of the war he was given charge of the Light Railway Workshops, and at a later date was put in charge of the Carriage and Wagon Works for the Army in France. Colonel Rudgard succeeds Mr. D. C. Urie, who is retiring, and Mr. J. W. Watkins has been appointed divisional superintendent at Derby in his place. The appointment is also announced of Mr. W. H. Roberts as the estate manager of the railway in place of Mr. W. H. C. Clay, who is retiring.

New Powers of Works Inspection

A NEW Order, which has been made by the Minister of Production under the Defence Regulations (No. 2432 of 1942), which came into force on Tuesday, December 1st, places the Minister of Production among the competent authorities who are empowered to direct firms to keep prescribed books, accounts, and records, and who may also send representatives to inspect premises and carry out any test or other investigation and take samples of any material or product treated at such premises. It may be recalled that hitherto the Regional Controllers of Production, the Minister's direct representatives, have had no power of inspection in order to examine the efficiency of management or plant or the nature of the work done. The object of the new Order is to repair that omission. About five weeks ago it was announced by the Minister of Production that a new policy for the distribution of sub-contracts had been decided upon, so that complicated jobs should be allocated to factories and plants with the highest skilled management and possessing the highest degree of tooling and equipment. Simple jobs under the same policy will be directed to factories and plants with equipment for less elaborate tooling. Other competent authorities under the Order are the Admiralty, the Secretary of State for War, the Minister of Labour and National Service, the Minister of Supply, the Minister of Aircraft Production, and the Minister of Works and Planning.

Merchant Navy Scholarships

IT is announced by the Ministry of War Transport that scholarships for boys who intend to become deck officers in the Merchant Navy are now available as follows:—The Nautical College, Pangbourne, Berks, £70 per annum for three years; H.M.S. "Conway," Tower Buildings, 22, Water Street, Liverpool, 3, £70 per annum for two years; H.M.S. "Worcester," Greenhithe, Kent, £70 per annum for two years; T.S. "Mercury," Hamble, Southampton, £45 per annum for two years; and University College, Southampton, £60 per annum for one year. These have been made possible by the generosity of Mr. H. P. Drewry, and the successful candidates will take up their studies next autumn. Candidates must be the sons of navigating or engineer officers of the Merchant Navy or R.N.R., who have been killed or seriously disabled by enemy action or who have died during the war while still in service, but not as the result of enemy action. Candidates should be fourteen to fifteen years of age, and should make their own application to the Principal of any of the establishments named above, not later than February 6th, 1943. The sum of £10,000 has been given by Mr. H. P. Drewry, a British merchant and shipbroker, formerly resident in Paris, to provide scholarships for potential merchant navy deck officers. Mr. Drewry when making the gift expressed a wish to help the Merchant Navy with which his family had been closely connected for many years. As a merchant and shipbroker, extensively engaged in international shipping trade up till the outbreak of war, Mr. Drewry was fully aware of the need for maintaining and encouraging a strong Merchant Navy, and has for many years made a close study of this subject. During the last war he served with his father and two brothers in the Royal Navy. His younger brother, Lieutenant G. L. Drewry, V.C., R.N.R., was killed in the Dardanelles engagement, while his elder brother, Engineer-Lieutenant H. Drewry, took part under Admiral Beatty in the Battle of Jutland.

Historic Accidents and Disasters

No. XVIII*

THE BOUZEY DAM

THE design of an earthen dam—such as that at Bradfield, near Sheffield, the disaster to which in 1864 was described in No. XVII of this series—is not based on mathematical calculations of its equilibrium and the pressure which it can bear. A glance at the cross section of any such dam, whether it has proved successful or has failed, will show at once that considerations other than the stability of the structure against the pressure of the impounded water dominate the design and dictate the employment of a form which is completely safe against overtoppling.

It is quite otherwise in the case of a masonry or concrete dam. In the design of such dams mathematical calculations—at least in modern practice — play a very essential part. Unfortunately, however, the mathematical analysis of the stresses and strains in a cyclopean or monolithic dam is, even to-day, influenced by the necessity for making numerous arbitrary assumptions and, in addition, has to be approached on a tedious "trial and error" basis. In short, the design of dams of all forms is a subject in which the guidance of mathematics has to be tempered in large measure by knowledge acquired through experience—generally bitter experience.

Even Rankine's highly respected "middle-third" principle, widely applied by the designers of masonry and concrete dams, is based on an arbitrary assumption, the validity of which has never rigorously been proved experimentally or otherwise. The faith reposed in that principle is justified, not by the unimpeachable character of its background, but by the cold fact that most dams designed in accordance with it have been successful, while some in the design of which it has been neglected have been disastrous failures.

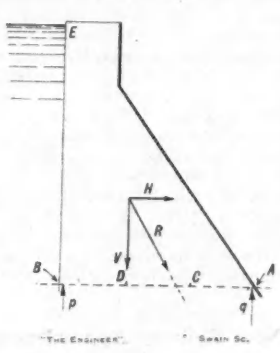
The Bouzey dam across the valley of the River Avière, near Epinal, France, provides an example of a dam in the design of which the middle-third principle was flouted. Let us therefore begin our story of the catastrophe which overtook it in 1895 by briefly recalling the nature of this principle.

Let A B represent any horizontal plane within the mass of the dam. Let V be the weight of the portion of the dam above this plane. Let H be the total horizontal force of the impounded water against the upstream face B E. Then the principle states that the resultant R of these two forces should act in a line which cuts A B somewhere within the middle third C D. If this rule is observed, then the stress imposed on the material of which the dam is built will be compressive at all points on the plane A B. If the line of action of the resultant cuts A B outside the middle third, then the stress in the material will pass from compression to tension either towards A or towards B. The principle is therefore designed to secure the avoidance of tensile stress at any point within the dam.

Maximum economy of material will be ensured if, when the dam is full, the resultant passes through C and if, when the water level is lowered to B, the resultant passes through D. In the full condition the stress across A B will then be just zero at p and increase compressively to a maximum at q; in the lowered condition the stress will be zero at q and increase compressively to a maximum at p. The fulfilment of these two conditions completely determines the thickness A B which the dam should have at any depth E B. The section thus arrived at is generally only the first approach to the final design and is modified in accordance with considerations arising from a more elaborate analysis. These considerations take account of the possible failure of the dam by shearing across the plane A B and, particularly in the case of high dams, of possible failure as the result of the development of tensile stress across planes at right angles to A B.

The middle-third principle, it should be noted, rests upon the somewhat doubtful assumption that the reaction stress applied by the portion of the dam below A B to the portion above it varies from p to q in a strictly linear manner. A similar assumption, perhaps more readily justifiable, is to be found in the theory of beams, in which it is taken that the fibre stress increases in linear proportion with the distance of the fibre from the neutral axis.

It may also be noted that while the avoidance of tensile stress is certainly essential or



THE "MIDDLE-THIRD" PRINCIPLE

very desirable in a masonry dam with mortared joints, it is not essential in a reinforced concrete dam. The reinforcement is, in fact, introduced in order that tensile stresses may be safely borne with a resultant economy of material over the amount which would be required if the middle-third principle were rigorously observed.

The Bouzey dam was a masonry structure. It had a length of 1732ft. and ran in a straight line across the valley. It was therefore a pure gravity dam and did not obtain any of the strength required to resist the pressure of the impounded water by being arched in plan. Its function was to form a reservoir holding about 7 million tons of water and serving to feed the Canal de l'Est.

The ground on which it was built was of a complex character. The top soil was peat overlying a layer of sand and alluvial deposit. Then followed a layer of sandstone and schist, beneath which there was a layer of porous sandstone and grit. Finally came a bed of more compact sandstone overlying solid rock. From the peat to the rock the depth varied from 10ft. to 18ft. The dam was founded on the lowest bed of sandstone, but as this bed, although relatively compact, was certainly not impervious, a "guard wall" about 6½ft. in thickness and 9ft. deep was sunk to the rock bottom beneath the upstream face.

As originally designed, the dam appears to have had a height of about 66ft. above its foundation on the sandstone. In section it had a width at the top of a little over 13ft. This width was maintained for a depth of some 14ft., whereafter the downstream face was turned with a large radius to meet the lower inclined portion, which at the foundation level had a width of about 37ft. The erection of the dam was begun in 1878. During the execution of the work it was proposed that the height of the dam should be increased by some 6ft. 6in. The Department des Ponts et Chaussées protested against the course, but the Minister of Public Works overruled the protest and sanctioned the alteration.

The designer of the dam—his name is not known to us—had evidently his own ideas as to the form which such a structure should take. He was indifferent to the "middle-third" principle, being content merely if the resultant of the forces acting on the dam at any section fell within the body of the material. He cannot, however, be supposed to have been an engineer wholly unversed in mathematical theory. He seems to have gone to considerable pains to ensure that the joints in the masonry were disposed in such a manner that the resultant forces in action across them were normal to their plane. He was also, it is certain, quite aware of the fact that his design involved the existence of tensile stresses near the upstream face. It would appear that he had satisfied himself by experiment that the material of which the dam was to be constructed could safely bear a tensile stress of about 3000 lb. per square foot and a compressive stress of some 20,000 lb.

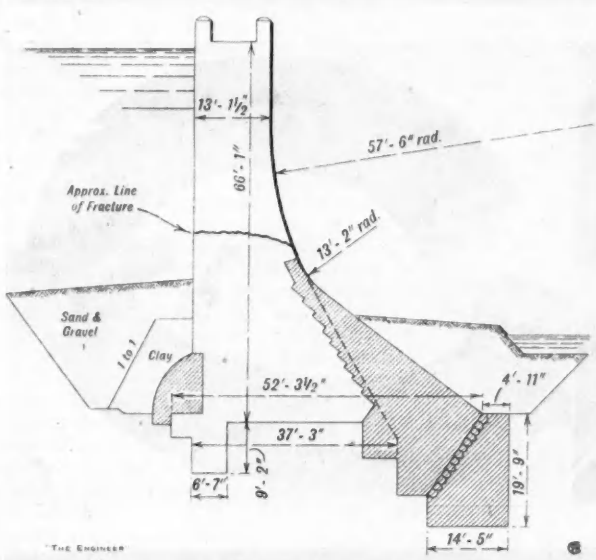
The construction of the dam occupied about two years and towards the end of 1881 the filling of the reservoir was begun. Almost at once springs were discovered on the downstream side of the structure, the leakage from which was estimated at 900 gallons a minute. About a year later two fissures appeared in the masonry, and as a precaution the water was maintained at a level 2½ft. below what was regarded as the normal safe value. On March 14th, 1884, these omens culminated in an alarming occurrence—or at least in one which should have caused alarm. On that date a portion of the dam measuring 450ft. in length suddenly slipped on its base and arched downstream, the maximum deflection amounting to about 15in. At the same time the flow from the springs below the dam increased to 1700 gallons a minute. The situation was ominous. Nevertheless, those responsible for the safety of the structure delayed taking action. Incredible though it sounds, they did nothing for eighteen months after the slip. The water level was maintained at the previous level and was even allowed to rise 7in. or 8in. higher. Doubtlessly there was some reason for the delay, but its nature is not recorded in any source of information which we have consulted. If there was a reason, it was probably not a technical one. It is impossible to imagine any engineer persuading himself that the dam was safer after the slip than before it, and that because it continued to show itself capable of impounding the water there could be no real cause for anxiety.

In the autumn of 1885 the engineers at last took action and drained the reservoir in order to make a thorough inspection of the dam. It was found that at the portion which had slipped the dam had separated from the guard wall and, in addition, that there were numerous fissures on the inner face, one of which, extending horizontally, measured 300ft. in length.

* No. XVII appeared November 27th, 1942.

It would certainly have been wise if at this stage a resolution had been taken to pull down the dam and build a new one. Nevertheless, although it must have been obvious to all concerned that something really serious was wrong with the design or construction, or both, it was decided to repair the dam. The repair works undertaken are indicated by the shaded areas in the accompanying cross section. The joint which had opened between the dam and the guard wall was closed by a block of masonry, over which a bank of puddle about 10ft. thick was placed. On the downstream side an abutment was built, and to it the thrust of the dam was transmitted by means of an inclined wall toothed into the original downstream face. In addition, the fissures were grouted and drains were placed in the masonry to carry off any water which might leak under the dam.

This repair work was carried out in a leisurely manner. It was not completed until September, 1889, five and a half years after the sliding of the dam had occurred. Having completed it, the engineers were now seized by a desire to get the dam back into service as quickly as possible. In



ORIGINAL AND REPAIRED SECTIONS OF BOUZEY DAM

November, 1889, within two months of the completion of the repairs, water was again admitted to the reservoir and was allowed to rise to a level even higher than that which prevailed at the time when the slip occurred in 1884. As the mortar could not have developed its full strength before the reservoir was filled, this proceeding must be considered to have been injudicious. Evidence that it was unwise was not wanting. Measurement showed that under the full load the repaired dam deflected by as much as ⅞in. in places. Still all was believed to be satisfactory and the dam once again was placed in commission.

For about five years it appeared that the engineers' faith in the repaired dam was justified. Then suddenly, early in the morning of April 27th, 1895, the dam cracked in a substantially horizontal plane at a level about 33ft. below its top and the whole upper portion, over a length of nearly 600ft.—including part of the length which had slipped in 1884—was swept away. The escaping water overwhelmed every house in the village of Bouzey. Passing on, it broke the banks of the Canal de l'Est, thereby adding to the torrent. The flood swept down the valley of the Avière for a distance of 10 miles until it discharged itself into the River Moselle. During its descent of the valley it destroyed or damaged six villages, a number of bridges, and part of a railway, and drowned well over a hundred people and thousands of cattle. The damage done to property was valued at about a quarter of a million pounds.

During the course of the inquiry into the Bradfield dam disaster the designer, Mr. Leather, delivered the statement that "all structures are bound to fail sooner or later." A similar fatalistic opinion was expressed in some quarters in explanation of the failure of the Bouzey dam. With a great show of sagacity these people attributed the disaster to the operation of a mysterious "*force majeure*" and left it at that. Others, equally inspired by a desire to blame Nature for the catastrophe, invoked a mythical seismic disturbance, just as at Bradfield a land slip was held by many to have been the hidden cause of the failure. Yet others spoke of the action of severe frost on the structure during the preceding winter.

Scientific engineers approached the subject analytically. They proved that from the start the dam had been exposed to tensile stresses near the upstream face. For example, it was shown that, assuming the dam to be wholly sound, a tensile stress of 2345 lb. per square foot would exist at the upstream face and a compressive stress of 9772 lb. at the downstream face at the level at which the dam finally failed. This result did not contribute much towards discovering the cause of the disaster. It had been known from the first—by some at least—that the designer, by ignoring the middle-third principle, had deliberately incurred the presence of tensile stresses in the structure. Further, the results of the analysis showed that the stresses in existence were less than those which the designer believed the materials employed could safely withstand, namely, about 3000 lb. in tension and some 20,000 lb. in compression.

Was the designer, then, in error in adopting these limiting stresses? So far as the limit for the compressive stress is concerned, neither the practice of his own time nor the practice of to-day can be said to condemn him. Modern rules for first-class masonry limit the maximum compressive stress to about 22,500 lb. As for the limit placed on the tensile stress, he could, if challenged, have pointed to two dams in Algeria, one of which was successfully withstanding a tensile stress of over 2000 lb. and the other a tensile stress of more than 6000 lb. per square foot.

Had he been rash in believing that the material at his disposal for constructing the dam would come up to the normal standard? The stone employed was re-tested after the disaster. Its strength characteristics were found to be considerably lower than those on which the designer had based his calculations. We have no record, however, of what the figures actually were. In a contemporary issue of THE ENGINEER we have found a reference which would seem to imply that the ultimate or failing strength—*not* the safe stress—of the material employed was about 13,000 lb. per square foot in compression and only 700 lb. in tension. We feel no confidence in the accuracy of either of these figures. That for the tensile strength is certainly too low—5 lb. per square inch—for anything worthy of being called, or treated as, stone. Besides, if we accepted it as correct, we would have to explain how the material managed to withstand, not simply momentarily, but for about two years, a stress three or four times as great as its ultimate strength.

In all the accounts of the disaster which we have studied information is lacking as to whether the fracture which ended the existence of the dam in 1895 passed through the stonework or followed, wholly or in part, the plane of one or more of the mortar joints. This is an unfortunate omission, because it prevents our seeking a possible cause of the catastrophe in a lack of strength at the joints rather than in the stone blocks. That the mortar was weak is certain. After the disaster it was established that it did not conform with the designer's specification. He had intended that cement mortar should have been used, but the contractors substituted lime for the cement and, in addition, mixed it with sand which was dirty and of a bad quality.

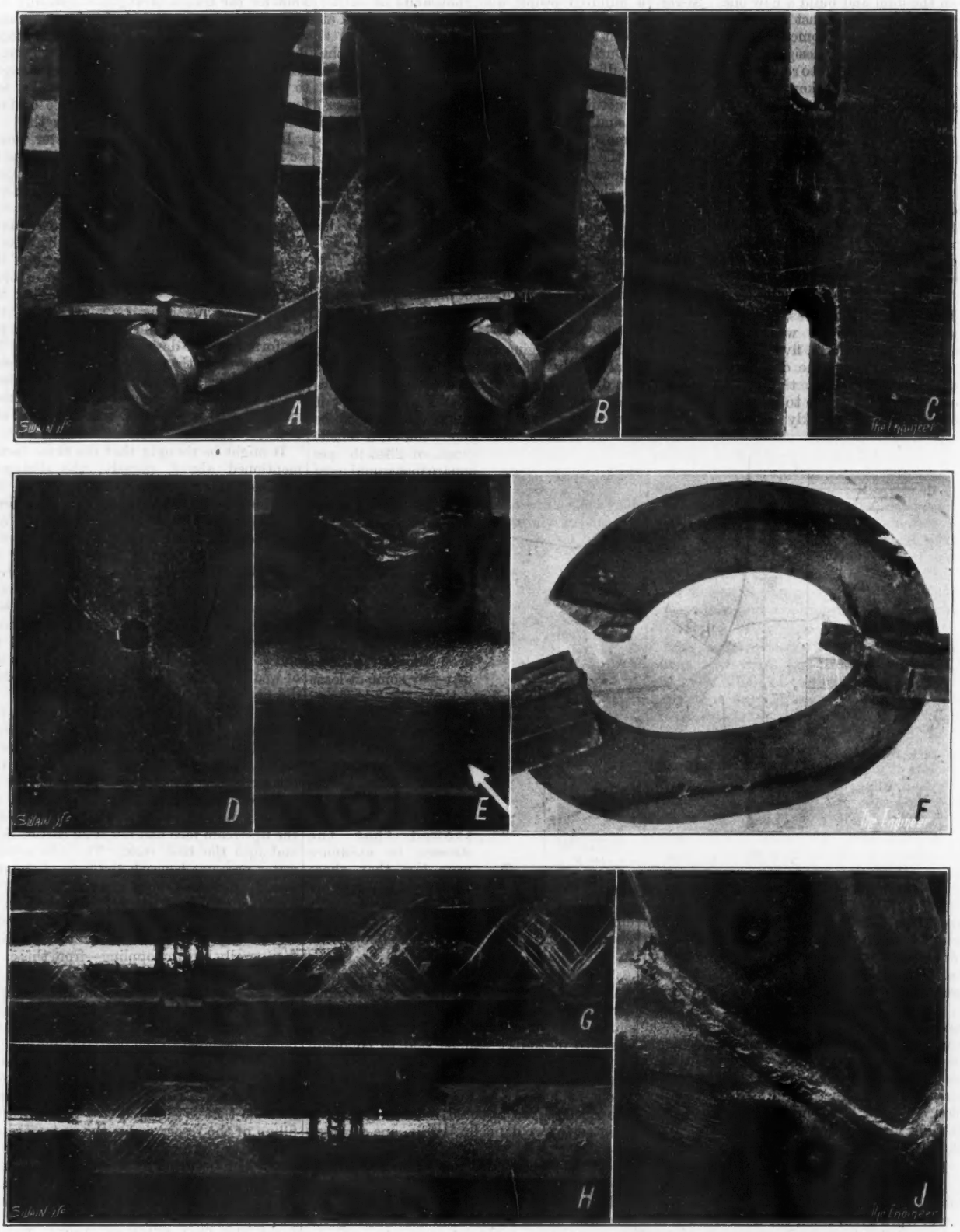
It might be thought that the three factors mentioned above, namely, the designer's neglect of the middle-third principle, the inferior quality of the stone, and the inferior quality of the mortar, are, taken in conjunction, sufficient to explain the eventful history of the Bouzey dam. This, at the most, can, however, only be partially true. Each of the three factors was fully effective from the start and if they alone had been potent the dam should have failed immediately the reservoir was first filled at the end of 1881. As it was, the first serious sign of weakness, the slipping of part of the dam, did not appear until March, 1884.

Some additional factor was clearly at work. Current opinion found it in the application of an uplifting pressure applied to the base of the dam. It can be accepted as certain that the sandstone on which the base rested was fissured and far from being impervious, and that in places the guard wall at the foot of the upstream face had not been carried down and into the base rock. The admission of water pressure beneath the base of the dam would, of course, very materially affect the stability of the structure as designed on the supposition that the foundation was watertight. Many dams are known to have failed—generally by overtoppling—from this cause.

That there was infiltration of water beneath the base of the Bouzey dam must be accepted as true. Nevertheless, it is difficult to understand how it could have been the culminating factor which led to the partial failure of 1884 or the final failure of 1895. If the sandstone strata on which the base rested were as porous as we are led to suppose, it is unbelievable that it required two years after the filling of the reservoir for the water pressure to build up to a value sufficient to cause the slip which occurred in 1884. It is still more unbelievable that it required five years for the pressure to build up beneath the base of the repaired dam to an extent sufficient to cause the final failure in 1895. Further, when the dam tore away from the guard wall in 1884 the access of water to the base of the dam must have been facilitated. Yet, as we know, the dam remained unrepaired and in full service for a further eighteen months.

An alternative contemporary theory was that water pressure was admitted into a horizontal crack in the upstream face of the dam at some level above the base. Such a crack as we have recorded was discovered when the reservoir was emptied in 1885. It

RESIN METHOD OF INDICATING YIELD



A.—First Lüders' lines appearing under combined stress due to internal pressure and bending. **B.**—Later development of Lüders' lines. Note that original Lüders' lines have broadened considerably and that many others have appeared, some crossing them. **C.**—Enlarged view of Lüders' lines in a test piece with two saw cuts to cause stress concentration; width between saw cuts 0·6in., thickness ¼in. Note symmetrical arrangement and evidence of stress concentration at corners of the notch. The lines first appeared at a stress of 12·1 tons per square inch, while the yield point of the material without stress raisers was 14·6 tons per square inch. The stress-raising factor is therefore 1·21. **D.**—Enlarged view of centre of tensile specimen, 0·6in. side by ¼in. thick, having a 0·05in. diameter hole drilled centrally through it. Note stress concentration round the hole. The first Lüders' lines appeared at a stress of 12·8 tons per square inch, which indicated a stress-raising factor of 1·14, taking the yield point of the material as 14·6 tons per square inch. **E.**—Arrow shows crossed Lüders' lines due to bending action. **F.**—The distortion in this case has reached such a large extent that the initial Lüders' lines have practically disappeared, although traces of them can be seen where the resin still partly adheres. The important point to note, however, is that the resin still adheres strongly along the neutral axis, where no distortion has taken place. **G.**—Tension test on welded joint showing early stage in development of Lüders' lines. **H.**—Later stage in development of Lüders' lines shown in **G**. Note that although the majority of the tube has yielded, there is as yet no sign of yield at the welded joint. **J.**—Lüders' lines due to combined stresses occurring at a welded branch under internal pressure.

was duly repaired before the dam was placed in service again in 1889, but may conceivably have reopened subsequently.

The admission of water pressure into a horizontal crack in the upstream face of the dam would apply an additional turning moment to the portion of the structure lying above the level of the crack. Further, the reduction of the cross-sectional area of the dam by the extent to which the crack penetrated the masonry would result in an increase in the stress to which the structure was subjected at the level of the crack. It was subsequently calculated that a horizontal crack about 3ft. deep at the level at which the dam finally failed would subject the structure at that level to a compressive stress of 12,000 lb. per square foot at the downstream face and to a tensile stress of 3762 lb. at the foot of the crack.

This crack theory does not seem to be at all adequate to explain the events connected with the earlier part of the dam's history. If the crack discovered in the upstream face when the reservoir was emptied in 1885 played any part in causing the dam to slip in 1884, eighteen months previously, it must have developed either before, or simultaneously with, the slipping. There is no evidence, and there never was any, to show when it occurred. If it followed the slip, as it might quite well have done, it could have been a result of the slipping, but it certainly could not have been the cause of it. If the crack were formed before or simultaneously with the slip and were the cause determining it, it is difficult to understand how the dam, weakened by the crack, managed to remain effective during the eighteen months between the slipping and the emptying of the reservoir. Further, it is hard to see how the admission of water pressure to the crack could cause the dam to slide bodily forward on its base. The effect that would be expected would be the overtoppling of the portion of the structure above the level of the crack. It is fundamentally fallacious to suppose that the presence of water pressure in the crack would lower the pressure of the structure on its base and thereby reduce its frictional resistance to sliding.

Applied to the events leading to the final failure of the dam the crack theory is reasonable enough up to a point. It agrees with the fact that the final failure consisted of the overtoppling of part of the upper portion of the structure. It has to be noted, however, that the existence of an effective crack at the level of the final failure is an inference from the previous history of the dam and is not confirmed by any direct evidence. Further, if there were such a crack, it must have developed just before the dam failed. It is unbelievable that the structure could have existed with a serious crack in it for any considerable part of the five-year period between the refilling of the reservoir in 1889 and the final failure in 1895.

We have now mentioned five factors, all of which undoubtedly played some part in determining the history of the Bouzey dam. A detailed survey of all the events strongly suggests that there must have been a sixth factor at work. This missing factor, it is clear, should be one having an equal bearing on the early slipping of the dam and on its final failure. Further, it should be one the harmful effect of which must have increased with the passage of time. We can picture it as some influence which grew from nothing at the start until in March, 1884, it reached a value sufficient to cause—or, in conjunction with the other adverse factors, to determine—the slipping of the dam. In some way or other the slip checked the activity of the unknown factor during the succeeding eighteen months or at least stepped its effect down to a level sufficient—possibly just sufficient—to ensure the survival of the dam for that period. Following the emptying of the reservoir, and while the dam was being repaired, the factor was quiescent, but when the reservoir was refilled in 1889 it again became active. Operating now on a structure possessing increased or renewed resistance to its attack, it required five years or so to reach a value sufficient to determine the final failure.

On this basis the missing factor may be conceived to be one analogous to the phenomenon of "creep" in metals at elevated temperatures, the circumstance deciding its activity being the presence of water in the reservoir.

It is not fanciful to trace this sixth factor to the mortar used in the construction of the dam. As we have recorded, it was made with lime instead of with cement, as had been intended, and, in addition, the sand was dirty. The employment of lime mortar in any stress-bearing masonry structure demands the exercise of much greater care on the part of the workmen than does the employment of cement mortar. The setting time is considerably longer and, in the presence of moisture and in the absence of free contact with the air, may be very prolonged indeed. It is also a well-established fact that if the mixing of lime mortar is performed carelessly some of the lime may pass into the mortar in the unslaked or partially slaked condition. Subsequent absorption of moisture will complete the slaking, but during that process the mixture of lime and sand will increase in volume. The expansion of a lime mortar carelessly prepared may continue progressively for many months after the mortar has been laid.

It is not difficult to perceive in what manner this expansion of a lime mortar would gradually reduce the strength of a dam in the construction of which it had been used. An actual instance of a disastrous failure which was attributed by some authorities to this very cause is provided by the bursting of the Habra dam in Algeria in 1881, some eight years after it had been brought into use. This masonry structure exceeded the Bouzey dam in height, but by all accounts it was well designed, the stresses everywhere being purely compressive. It burst following a severe rainstorm with fatal results to more than 200 people. The mortar used in its construction was composed of clean, but unduly fine, sand and of an inferior quality of lime obtained locally. During the course of its life the dam gradually developed a desposit of carbonate of lime on its downstream face, clear evidence of the fact that there was an excess of free lime in the mortar and pointing unmistakably, in the opinion of some authorities, to the expansion of the mortar as the prime cause of the disaster.

The application of this factor, even in conjunction with the other factors we have named, to the case of the Bouzey dam may not completely solve all the mysteries connected with its disastrous failure. It does, however, help to resolve some of the perplexities and to reconcile some of the apparent inconsistencies which a study of the catastrophe presents to us. Taking a broad view, it enables us to pronounce with assurance a general verdict on the disaster. The Bouzey dam failed because in it bad design was allied with inferior materials and defective workmanship.

The Resin Method of Indicating Yield

By J. S. BLAIR, B.Sc., A.M.I. Mech. E.*

IT has long been known that the occurrence of yield at the surface of structural or other members can be detected by the falling of scale from the surface. This effect can be enhanced by whitewashing the surface prior to testing, the whitewash flaking off with the scale and showing the occurrence of yield more clearly. Even greater improvement, however, is obtained by coating the metal surface with resin. This not only indicates yield, but allows observation of individual Lüders' lines and the position of localised stresses, and also permits a certain degree of stress analysis. It is not certain who originated the use of resin in this way, but the method was very considerably developed by the late Professor B. P. Haigh.

The method is especially useful for detecting yield in the case of complicated stresses or elaborate structures, welded designs, &c., particularly when it is not known at what part of the structure yield is most likely to occur first. It has been used on complex bridge type structures up to 100ft. span, every part of which has been covered with resin, and also in the investigation of the effects of pressure stresses on fabricated tubular articles. In fact, it can be used for practically every stressing problem at atmospheric temperatures, for either simple or combined stresses, and it gives more information about the localisation and extent of stresses than any of the more common methods, such as the use of dial gauges, extensometers, &c.

It seems surprising that, in spite of this method having been known for a large number of years, it is not more used both in research, testing establishments, or in teaching, the latter especially, since the method is particularly suitable for demonstration to a large number of people simultaneously. This may be due to reports of unsatisfactory results. Where it has been possible to investigate such reports it has been found that they have been almost invariably due to faulty application of the resin. The proper technique is easily acquired, but it is essential to adhere to it closely.

Application of Resin

The exact method of application of the resin is very important, since it is essential that the resin coating be as brittle as possible, no elasticity of any sort being permissible. This precludes the use of solvents, and it is therefore necessary for the resin to be put on in the dry condition by the application of heat, the resin being melted on to the surface at a temperature about 140 deg. Cent., *i.e.*, 30 deg. Cent. above the melting point of the resin. Large adherent particles of mill scale should be removed with a scratch brush, but fine scale particles or rust will generally not affect the method appreciably. Any coating, such as paint, must, of course, first be removed. If the test piece is small, the best method is to dip it into a bath of

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molten resin at 140 deg. Cent. The test piece should be left in the bath for a sufficient time for the whole of it to reach the temperature of the resin and then withdrawn and allowed to drain. The coating will then be of about the right thickness, too thick a coating being inadvisable.

Larger test pieces may be coated partially or wholly by heating the surface with a blow-lamp and coating them piecemeal. The resin may be applied either (*a*) by rubbing the surface with a lump of solid resin, (*b*) by dusting powdered resin on to the surface, or (*c*) by brushing the resin on in the molten state. Method (*b*) is particularly suited to large structures where the members are not easily accessible.

The temperature is very important, since if it is too high the resin will either burn or run off and leave practically no coating ; but, on the other hand, if it is too low the resin will stick and not properly " wet " the surface. As previously mentioned, a temperature of about 140 deg. Cent. is suitable, but a little experience will soon form a much better guide to the conditions than any actual temperature measurement.

If the surface is not sufficiently smooth after coating in this way, the blow-lamp or heating flame can be run rapidly over the surface so as to smooth off the resin. This practice, however, if carried out on a completely cold surface, may lead to the formation of shrinkage cracks in the resin, and considerable care should be taken to see that such cracks do not occur, since they will make it difficult to distinguish subsequent Lüders' lines.

Results Obtained

The method can be applied to any sort of test specimen, although, of course, it is more useful in the case of complex stresses. It is possible in certain cases to detect fine cracks in the resin at right angles to the axis of stress at considerably lower stresses than would cause yield. These cracks are due to the elastic deformation of the steel and do not generally extend through the thickness of the resin. They are unlikely to be confused with the true Lüders' line cracks, which are generally inclined to the axis of stress and extend right through to the surface of the resin and result in flakes of resin falling off the specimen. These falling flakes can be seen as scintillating specks in suitable transverse illumination, and this is a particularly useful feature when large structures are being tested, since the actual Lüders' lines may be out of view, but the falling specks of resin may be visible. The progress of yield over the surface of a test piece can be clearly followed by watching the lines broaden, spread, and appear at different points. Finally, during the progress of plastic elongation, the resin will flake off almost entirely from the surface of the test piece. It may be found that because of the sensitiveness of the method an odd Lüders' line or two may appear quite early in the testing, due perhaps to slight stress concentration at the grips, excentric loading, &c. If these are only local stress relief lines they will not spread continuously, and after a little practice can easily be distinguished from those due to general yield of the specimen.

Stress Raising Factors

The resin method is particularly useful in structures where the design is such that certain parts act as stress raisers, as the position of these parts will be indicated by Lüders' lines appearing before the general yield of the structure occurs. By comparing the magnitude of the load at which these earlier Lüders' lines appear with that at which general yield is indicated the relative stress-raising factors can be evaluated. Thus, the resin method can be employed to give similar results to those obtained by the use of polarised light with transparent models, but the resin method is simpler and is free from the necessity of relating model performance to the actual structure.

Type of Stress and Stress Distribution

A great deal of information as regards the type of stress involved can be gathered from the shape, type, and distribution of the Lüders' lines, but this, of course, applies to any method of showing up the lines and is not peculiar to the resin method, and is not therefore dealt with here. The falling of scale from a yielded part of a structure allows, in some cases, the Lüders' lines underneath the scale to be seen, but this is not always the case, and it is difficult to estimate the direction and details of these lines with certainty. A direct examination for Lüders' lines in metal generally requires that the metal surface be specially polished and prepared, such preparation not usually being practicable when testing structures. A commonly employed method of testing complex structures is to attach extensometers or dial gauges at as many points as possible over the surface of the structure. While such procedure may indicate the first point of yield, provided the extensometer has been placed at the most highly stressed point, little information is obtainable about either the type of stress or its distribution. Furthermore, this method is extremely costly and at best only a limited part of the surface can be covered by extensometers, and the interpretation of the results of such tests is very difficult.

Considerable use may be made of the fact that where no Lüders' lines are present in the resin, the underlying material has not yielded. Thus, tensile test pieces, &c., representative of the original condition of the material, can be cut from those parts of the structure which remain unstrained after testing.

The illustrations on page 454 show various applications of the resin method, and it will be seen that in most cases the Lüders' lines are easy to photograph. Where difficulty is experienced, however, the contrast can generally be considerably enhanced by rubbing french chalk into the lines.

It is hoped that this description of the resin method may prove of use to those carrying out tests on complex structures.

Deep Tunnel Air Raid Shelters

No. II—(*Continued from page 446, November 27th*)

Electrical Equipment

A DUPLICATE supply of electric power and lighting was decided upon in order to minimise the risk due to breakdown of services during bombing. The main supply comes from the local supply authority, and it is in all cases at 400 volts, 50 cycles, three-phase, except at one station, where it is 460 volts, 50 cycles, single-phase. The second supply comes from the London Passenger Transport Board system. The four stations south of the river are fed by means of a special 11,000-volt, 33⅓ cycles, three-phase feeder with transformers at each station to step down to 400 volts, 33⅓ cycles, three-phase ; while on the north side of the river the Board's existing D.C. supply at 600 volts is used for power and the existing A.C. lighting supply at 230 volts for the emergency lighting. All incoming supplies, both from the local supply authority and from the L.P.T.B., are led to a control room (Fig. 5) down below situated near the ventilating fans. By means of change-over switches either supply can be used for power, either directly, when D.C., or by means of a mercury arc rectifier when A.C. All the ventilation and sanitation plants and the lifts run on D.C. current. The switch capacity of each control room (there are two for each shelter) is approximately 150 kW.

Mercury arc rectifiers were supplied by the Hewittic Electric Company, Ltd. Each is of 630-volt, 111-ampere rating, and is housed in a steel cubicle situated at the end of the control room. Alongside it and enclosed in a separate chamber is its 70-kVA, 400/600-volt, Hackbridge oil-filled transformer, with an input of 118·5 amperes and an output of

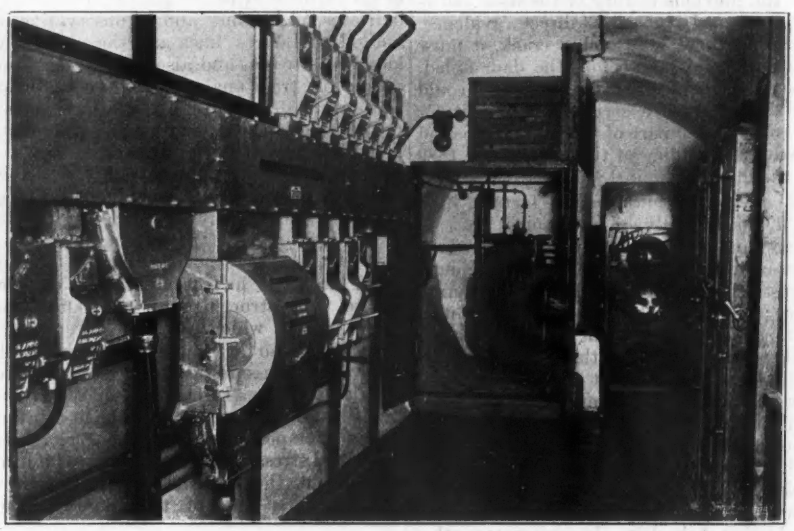


FIG. 5—CONTROL ROOM

32 amperes. Should a fire occur, this chamber is automatically sealed and a special CO_2 equipment comes into action to deal with the outbreak. The output from the rectifier is connected to the D.C. switchboard through a circuit breaker. To keep the electrical equipment in good condition tubular heaters

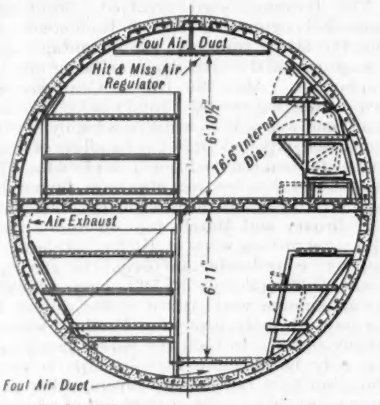
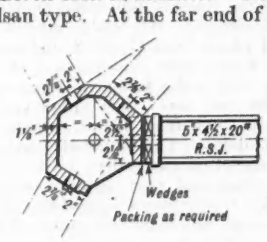


FIG. 6—SECTION OF SHELTER TUNNEL

loaded at 2½ kW are installed in each control room. All the electrical services are in welded conduits with electric thread.

SANITATION

At each shelter eight lavatory tunnels were driven 12ft. in diameter. Closets are of the Elsan type. At the far end of each lavatory a hopper has been installed, into which the closets are emptied. To keep out bottles, boots, clothing, &c., all of which have been found to give trouble in other shelters, it was necessary to install a wire screen. The hoppers are connected by piping to a closed ejector placed in the bottom of the staircase shafts, and the contents of the ejector are periodically forced out by means of compressed air through a rising main, 6in. diameter, up to sewer level in the street above.



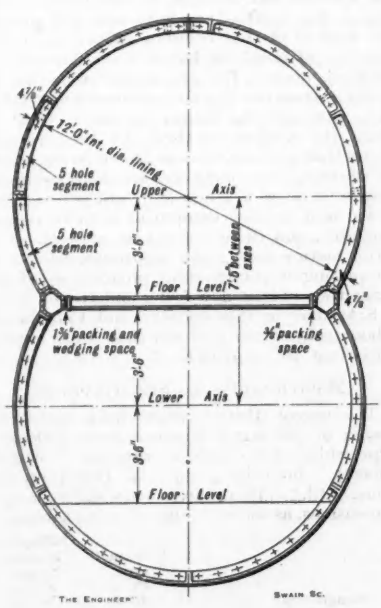


FIG. 7—SECTION AND DETAIL OF SUPERIMPOSED TUNNEL

Eight of the ejector systems were supplied by Hughes and Lancaster, Ltd., and eight by Adams-Hydraulics, Ltd. Both plants consist of an electrically driven air compressor of 18 H.P., that charges up an air receiver tank to a pressure of 100 lb. per square inch. The total head is approximately 120ft. and sufficient air has been provided to allow of the ejector itself, which is of 100 gallons capacity, being operated at the rate of once a minute. The piping system is equipped with isolating and reflux valves to avoid the risk of flooding back to the lavatories.

The chemical closet type of sanitation was selected in preference to a completely water-borne system, as it can function even when power or water supplies fail through bombing and because it is more resistant to abuse and greatly diminishes the amount of water to be ejected. A water storage tank with a capacity of 3000 gallons was installed at surface level near each shaft in case the public supply was interrupted by bombing. A sewage storage tank with a capacity of 5500 gallons was installed at the bottom of each shaft, ensuring about a five days' storage for the contents of the closets and urinals only, if the ejector system should fail from any cause.

BUNKS

As will be seen from an accompanying section drawing—Fig. 6—and the half-tone illustrations in our last issue, bunks are arranged crossways on one side of the gangway and longitudinally on the other side in all parts of the shelter. The cross bunks are arranged in three tiers. Their framework is of steel and they are fitted with spring mattresses, except on the middle tier. Here there are wood laths that can be used as a seat, and the top tier is so made that it will fold down to form a back rest. Each bunk is 2ft. wide, and the space between bunks is also 2ft.

Some difficulty was found in developing a satisfactory design for the longitudinal bunks, and several models were tried before the design could be regarded as satisfactory. Some of these bunks are 2ft. wide, others 1ft. 9in. wide. This difference was brought about by the need to maintain a gangway between the bunks sufficiently wide for circulation of the shelterers, wardens, &c.

CONSTRUCTION

As soon as instructions had been issued that the works were to be put in hand, detailed studies were made of a number of sites, and borings were sunk to determine the nature of the strata. Contracts for the works were arranged with five contractors, all with long experience of tunnelling in London—Kinnear, Moodie and Co., Charles Brand and Son, Ltd., John Cochrane and Sons, Ltd., Edmund Nuttall, Sons and Co. (London), Ltd., and Balfour, Beatty and Co., Ltd., respectively. Shafts that eventually accommodated the spiral staircases were used as working shafts, and were begun as soon as their sites had been acquired. Each was 16ft. diameter where cast iron was used for lining and 16ft. 6in. diameter where reinforced concrete lining was used. Each shaft was sunk ring by ring by underpinning in the usual way. Rings were 20in. deep and each consisted of eight segments, and one key bolted together and caulked where necessary to prevent seepage. Hoisting gear, air compressor plant for pneumatic tools, grouting machines, and other equipment were installed at the top of each shaft, and so shrouded that work could be carried on during the blackout as well as by day. Carting away of muck was done by day only, and the muck stages were therefore sufficiently large to accommodate all muck excavated by night.

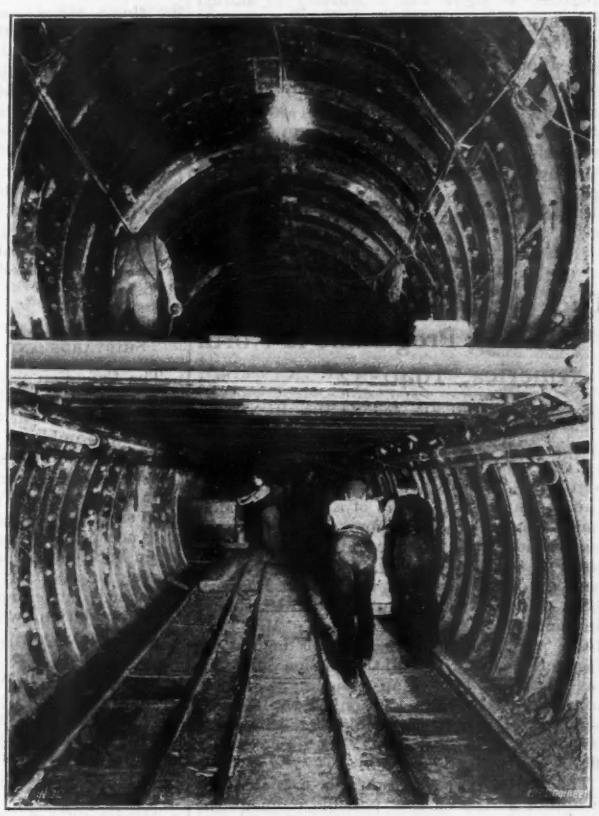


FIG. 8—SUPERIMPOSED TUNNELS

As soon as a shaft had been sunk to its full depth and bottomed, horizontal passages, 12ft. diameter, were driven towards the site of the tube shelter tunnels. These passages were either entirely separate or alternatively superimposed, as illustrated in Fig. 8. The lining was of cast iron. Construction of superimposed passages was conducted in a way that had never been attempted before. A cross-section drawing is reproduced in Fig. 7. The lower passage was kept about two rings ahead of the upper, and the upper part of this passage was not excavated, but was supported by the joists that carried the intermediate floor. Timber poling boards provided support for the clay until the upper passage had followed on. Since separate gangs could work in each passage, progress

in making a double-decker tunnel was as rapid as that in making a single tunnel, and averaged about two rings per shift of twelve hours.

Once the site of the shelter tunnels had been reached, headings were driven out or enlargements made and the construction of these tunnels was begun. In view of the facts that the drives were in any case short, and that considerable delay would have been incurred before shields of the 16ft. 6in. size could be obtained, the work was in the majority of cases done by hand. Erection of the lining followed closely upon excavation, and so soon as every two rings had been completed the work was made solid by grouting the space between the outside of the lining and the excavated ground. The usual face gang consisted of one leading miner, two miners, and four unskilled labourers. Considerable difficulty, however, was experienced in obtaining a satisfactory rate of progress, as there was a scarcity of skilled miners, and, working two shifts, the average progress per shift was never built up further than about two rings per shift. One of the contracting firms—Kinnear, Moodie and Co. —therefore contrived a special, somewhat rudimentary, shield, built up from material available, and by the use of this shield, working three shifts, progress was lifted to a rate of twelve rings per day.

(To be continued)

The British Merchant Shipbuilding Progamme in North America, 1940-42*

By R. C. THOMPSON and HARRY HUNTER

Preliminary and Negotiations

EARLY in September, 1940, the authors were invited by the Admiralty to proceed to the United States as members of a Technical Merchant Shipbuilding Mission, Mr. Thompson being head of the Mission and Mr. Hunter the marine engineer member. The other three members of the Mission were Mr. Wm. Bennett, B.Sc., principal surveyor of Lloyd's Register of Shipping for U.S.A. and Canada; Mr. J. S. Heck, principal engineer surveyor of Lloyd's Register, New York; and the Mission Secretary was Mr. R. R. Powell, an Assistant Secretary, Admiralty. Mr. John Robson, of the Department of Merchant Shipbuilding, Admiralty, joined the Mission in New York in February, 1941.

The object of the Mission was to endeavour to obtain at the earliest possible moment the delivery of merchant tonnage from U.S.A. shipyards at the rate per annum of about sixty vessels of the tramp type of about 10,000 tons deadweight. The work of the Mission was to be considered as completed at the stage at which orders were placed, or provisionally placed, and settlements made as to technical details. Before leaving, we were also informed that it was hoped that it would be found possible to arrange for the Mission to investigate possibilities of merchant shipbuilding in Canada, and this authority was actually received soon after we arrived.

We reached New York on October 3rd, and the first full meeting of the Mission took place in New York on October 4th. After making various contacts in New York and Washington, we met Todd Shipyards, Inc., and found they were associated with a group of Pacific Coast civil engineering contractors known as Six Services, Inc., headed by Mr. Henry J. Kaiser, and jointly they owned the Seattle-Tacoma Shipyard. They produced a nicely coloured drawing of a modern British tramp steamer, and offered to build ships for us, providing they had reciprocating engines and water-tube boilers—Scotch boilers might be possible—and a specification generally to meet the special conditions. We also met representatives of other shipbuilding concerns, several of whom undertook to look into the matter.

We then proceeded to Ottawa, and met Hon. C. D. Howe, Minister of Munitions and Supply, and his Director of Shipbuilding, Mr. D. B. Carswell—again it seemed that reciprocating engines were the only hope, and they could do Scotch boilers.

We then commenced a general examination of the possibilities in Eastern Canada, after which we returned to New York, meeting various shipbuilders and prospective shipbuilders, and on October 15th we started a tour of the American Continent, visiting existing shipyards and engine works, works which might build engines or boilers, and sites where shipyards could be built.

By this time, an association of Todd, Bath Ironworks, and Kaiser group, and also Burrards, Canadian Vickers, and Davie Shipbuilding Company had undertaken to submit tenders. We finished up with three contracts for each yard, in each case one being for the yard, one for thirty ships, and one being a guarantee contract signed by the respective stockholders. Contracts were signed on December 20th, 1940, as between His Majesty's Government, represented by the British Purchasing Commission, on the one hand, and Todd-Bath Iron Shipbuilding Corporation, Portland, Me.; and, secondly, Todd-California Shipbuilding Corporation, Richmond, Cal., on the other, covering the building of the two shipyards and thirty ships at each yard, in addition to guarantee contracts signed by the respective stockholders.

Shortly afterwards orders for twenty-six vessels were placed with various Canadian yards.

The Todd Bath and Todd-California Shipyards and Canadian Shipyards

The Canadian yards being in existence, we were only concerned with the U.S. yards and sites, and had to satisfy ourselves that what was proposed would (*a*) do the job and (*b*) do it without any unnecessary expenditure.

Richmond, California, and Portland, Maine, were proposed by Todd as being good sites in good situations as regards available labour, &c., and accepted as such. Each were to have seven berths. Richmond Yard was to be built entirely on piles and arranged as a normal yard as regards launching. Portland, which had a rock foundation, was proposed as a series of shallow dry docks or basins. It was agreed that, although the latter would take a little longer to build, it would not cost much more, and the ships would be cheaper and quicker built owing to being built on the level and eliminating launch costs. Actually, both yards cost us about the same amount, while the ships were produced more quickly at Richmond, due to causes referred to later.

The lay-outs of the yards are fairly similar.† Portland had 25-ton cranes, Richmond 35-ton, largely on account of delivery conditions. Both yards found out the difficulty of trying to build ships with one crane per berth, and various improvisations were adopted to get over this. On account of lack of space, Portland had to take over a large area of ground 3 miles from the yard, for storing steel, boilers, engines, and most of the other sub-contracted material. This storage space had a direct rail connection, which the yard had not, so special road vehicles were used between the two places, owing to high cost of laying rails and right-of-way difficulties. Richmond had direct rail access and storage on the site. The Portland yard was only possible as a shallow dry dock proposition on account of the particular nature of the ground where suitable rock foundations were found at the right level in association with a small rise and fall of tide. Even so, pumping had to be resorted to on a considerable scale, and this led to difficulties under the hard winter conditions encountered in this locality. It is, unfortunately, not possible to say which is the cheaper method of building on account of differences in conditions. The fact remains that Richmond delivered thirty ships by July, 1942, nineteen months from signing the contract, while Portland look like completing their thirty by November, 1942—within contract, but definitely second, in spite of the fact that many more people with shipbuilding experience were engaged at Portland.

The Portland yard involved considerably more civil engineering than the Richmond yard, and the latter yard had the advantage, as it transpired, of the civil engineer being also the shipbuilder. Also the Kaiser Company was just completing the big Grand Coulee dam contract, and was able to bring in a highly efficient team, well experienced in the handling of bigger contracts than the traditional shipbuilder. The West Coast weather was also more favourable, with no frost or blizzards, although the months of February and March were definitely damp. The construction work at Richmond, however, was very considerable, involving the driving of about 25,000 piles up to 70ft. long, which, at the maximum, were driven at the rate of 700 per day, while the ground at Portland was still largely frozen. In fact, the Kaiser group have not only built thirty British ships in record time, but they have set up several other yards comprising fifty berths or more, all of which are doing equally well, and they can claim to have set a high standard to the world in the mass production of good ships. Anyway, in the event they more than justified the confidence placed in them.

To return again to Canada. The contracts which we placed were with existing yards. Working plans had to be supplied from Britain —riveting was feasible and preferred by the Canadian builder, so our orders were placed for mainly riveted vessels following very closely the British design. We could have obtained the welded plans from the U.S. builders, but that would have meant building new shipyards or making very substantial modifications, as would be the case here. The equipment would have had to come from U.S.A., which would have meant delay. The Canadian yards therefore went ahead on our orders, on the basis of mainly riveting and part welding, and when the Canadian Government formed the organisation, Wartime Merchant Shipping, Ltd., to step up Canadian shipbuilding, that organisation followed our example and standardised our ships. The results they have achieved proved the wisdom of that decision. They made the best use of available labour and materials as we have done. The arguments in favour of welding *versus* riveting are far from being settled, and, although the former is put forward as being the modern method, all the evidence shows that it involves more labour in the building of ships. Its advantages are that less capital cost is involved if a new shipyard is being laid down, and welding equipment is more readily available, and there is a saving of steel. This latter feature is of great importance when contemplating a shipbuilding programme of the magnitude of that now being undertaken in the U.S.A., but in this country and Canada the labour side of the problem is at least equally important, if not more so.

Modifications to Specifications

The parent British vessel from which the design of the sixty American-built "Ocean" type ships was evolved was the "Empire Liberty," built by Joseph L. Thompson and Sons, Ltd.‡ There are slight differences in dimensions, as shown in the following tables:—

	"Ocean" type. Ft. in.	"Empire Liberty" type. Ft. in.
Length b.p.	416 0	416 0
Breadth—Ext.	57 0¾	57 2
Moulded	56 10¾	56 10¾
Draught—Ext.	26 10¾	26 11½
Moulded	26 10	26 9¾

Both types: Camber—Second deck, nil; upper deck, 14in.

Sheer—Second deck, nil; upper deck 8ft. 9in. forward, 4ft. 6in. aft.

To suit U.S.A. practice, to ensure a good supply of labour, to facilitate production, and to get the best value for money, it was decided

* Eleventh Andrew Laing Lecture, North-East Coast Institution of Engineers and Shipbuilders. Condensed.

† Some particulars with illustrations and plans of the Richmond and Portland yards will be found respectively in our issues of July 25th and August 1st, 1941.—ED., THE E.

‡ An illustrated description of this ship appeared in our issue of September 26th, 1941.—ED., THE E.

that the ships must be mainly welded. In fact, practically the only rivets left in were the connecting rivets of frames and shell. This was in accordance with established practice in a number of U.S.A. yards, though one or two preferred all-welding, while a number of others welded everything except shell seams. To produce an all-welded ship involves making elaborate formers for laying outside shell, correct to shape, in order to weld frames thereto down-hand. It was not considered that the number of ships involved in these contracts justified such a procedure.

Other modifications to the specification agreed upon were as follows :—

The substitution of cast steel or fabricated mild steel for cast iron—the latter is very little used in America and cast steel is very reasonable in price there. In fact, the cast steel stern frames were the only thing in the ship found to be cheaper in U.S.A. than here. Hawse pipes were made of cast steel, also fairleads, while bollards were fabricated mild steel or cast steel.

Electrical Fittings.—U.S.A. electrical practice was found to vary considerably from British, but it is too wide a subject to deal with in this paper. It is felt that firms handling this work in this country would find much of interest if they examined any modern American vessel.

Woodwork.—In the U.S.A. woodwork is almost invariably sub-contracted by the shipbuilder, so that furniture is designed for mass production and simply fitted on board. Wood decks are practically unknown, the usual practice being to insulate deck-heads in accommodation with asbestos wool, about 1½in. thick, interwoven with wire netting. This is fitted close to the steel and lined with plywood under. It may be mentioned here that pre-war American Rules did not allow wood in the accommodation at all, and all furniture was steel, while bulkheads and linings were made of thin steel bonded to asbestos. The general finish produced was such that it needed a knife to prove wood was not used. This practice was, however, much more expensive, so plywood was used in the British ships, and the American Rules have now been waived in their Emergency Programme to facilitate production. Teak was practically unknown, and American white oak used in its place.

The rudder was made of fabricated mild steel and cast steel, but according to a rather interesting American design, which apparently gives very good results.

Steering Gear.—As very few large American steam gears had been produced in recent years, it was decided to have gears manufactured in U.S.A. to British designs, and the same remarks apply to windlasses. Designs for the former were supplied by John Lynn and Co., Ltd., and the latter by Emerson, Walker, Ltd. The Taylor Pallister design was used for rudder carrier.

In Canada, it was found advisable to make modifications from both the American and British specifications, as referred to later. The Canadian yards were at that time all in existence, and mostly they not only had considerable repair businesses, but they were already building corvettes and minesweepers of mainly riveted construction. The Canadian yards wanted all plans supplied, so it was decided that they would work to British plans, but that individual firms could introduce more welding with our and classification approval. Revised plans covering introduction of additional welding were prepared by the Burrard Drydock Company, Ltd., for use in all Canadian yards. In Canada steel was in short supply, so that most of the yard facilities were made of wood, some of the work being very ingenious, such as 10-ton wood cranes travelling between berths and wood gantry cranes.

A big problem was involved by the lack of detail in British plans which required very considerable interpretation and amplification, but the members of the Mission were able to cover most points in this respect, and also arrangements were made for the representatives of the shipbuilders to inspect British ships of the type concerned in port. Other problems included difference in pipe and flange standards, and such items as U.S. or Imperial gallons, long and short tons, timber sizes, hemp and wire rope sizes, &c.

Another consideration which was very fully gone into in conjunction with Lloyd's concerned the scantlings advisable in a mainly welded ship. For instance, it was decided to keep the longitudinal, vertical, and horizontal moment of inertia of the section the same as for a riveted vessel. Also it might be mentioned that, with 30in. frame spacing, the plating span is only 26½in. from heel to toe of frame, whereas with welded structure the span is 29½in. To compensate for this, such things as keel thickness were increased 10 per cent. This has been proved necessary to avoid knife-edge effect when in dry dock. For these reasons, the saving in weight due to welding is not as much as might at first be expected. Our M.O.W.T. Regulations also required specific definition in both U.S.A. and Canada.

Centralisation of Design and Purchasing

Gibbs and Cox are a firm of consulting naval architects in New York, and they were employed not only to do all the work usually carried out in a shipyard drawing and design office, but also to purchase all materials required for building the ships, both hull and machinery. Only small items purchased locally were to be bought by the shipyards themselves. To give an idea of the size of this organisation, it may be mentioned that at the time of our discussions they were employing a staff of between 900 and 1000. In our case, their function was to produce a new set of plans, based upon those provided by us, but modified as regards the substitution of welding for riveting, and to suit American practice regarding sections obtainable, size of plates, pipes, &c. For instance, shell plates, 40ft. long by 10ft. broad, were obtainable, while bilge keels could only be obtained by cutting the flange off a bulb angle. Then Gibbs and Cox were to purchase all the major items—main engines, boilers, shafting, propellers, auxiliaries, steering gears, windlasses, joiner work, plates, sections, rivets, welding rods, stern frames, rudders, electrical installations, sidelights, boats, davits, upholstery, to name a few—and even bolts and nuts, and arrange for everything to be delivered at the shipyard at the right time. As an illustration of the detail involved in this work, it was their practice, in the case of large contracts, to make a model of the engine-room and everything in it, complete in every detail to a scale of ½in. to the foot, in order to determine the best lead of all pipes, electric cables, &c., all of which would be completed on the model and then incorporated on all drawings. In other words, nothing whatever was left to be arranged on the ship. This practice has been proved to save endless time and argument in the shipyards, where local surveyors were responsible only for seeing that all plans were exactly followed.

In the case of our contracts, a model of the machinery space was not made, as the British plans gave a good basis. In the case of the Maritime Commission "Liberty" class, such a model was made, the change to oil-fired water-tube boilers necessitating very substantial rearrangement. A model covering both classes of ships was made of the fore end in connection with anchor cable and paravane leads.

The wisdom of utilising the services of an organisation of this sort was confirmed by the fact that the U.S. Maritime Commission, when it started its Emergency Programme involving hundreds of ships, followed our example. Incidentally, they also accepted and followed our hull design, as well as our main engine design, and they also standardised on practically the same auxiliaries and equipment as those used by us. In fact, the main differences between our ships, the "Ocean" class, and the Maritime Emergency ships, "E.C.2" type, also known as the "Liberty" fleet, lie in their rearrangement of the accommodation to house the whole crew amidships, and the adoption of water-tube boilers and oil burning. It should be stated, however, that with the further extension of the Maritime Commission programme, involving thousands instead of hundreds of ships, they set up their own organisation in Washington.

(To be continued)

The Isaac Newton Tercentenary Celebration

At the 280th anniversary meeting of the Royal Society, which took place at the Royal Institution on Tuesday, November 30th, Sir Henry Dale was re-elected President. At that meeting the President, Council, and Fellows celebrated the tercentenary of the birth of Sir Isaac Newton on Christmas Day, 1642, at a modest manor farmhouse, in the hamlet of Woolsthorpe, near Colsterworth, 6 miles south of Grantham. In addressing the gathering, Sir Henry Dale announced the successful conclusion of negotiations to acquire and preserve the birthplace. The Pilgrim Trust, he said, will be responsible for the sum of money required for the purchase, which the Lord of the Manor of Woolsthorpe, Lincolnshire, has agreed to, at a price substantially less than its value. This tiny but historic property will now be put for as long as possible beyond the risk of damage or decay. In a lecture, entitled "Newton and the Science of His Age," Professor E. N. da C. Andrade, F.R.S., illustrated his subject, and said that if we were to try to represent Newton's achievement by some modern analogy, we might picture a man who, starting in 1900, say, had done the fundamental work of Einstein, Planck, Bohr, and Schroedinger, and much of that of Rutherford, Alfred Fowler, and Paschen, and had then become, say, by 1930, Governor of the Bank of England, besides writing two books of Hibbert Lectures and spending much time on psychical research, to correspond with Newton's theological and mystical interests. Only thus could we see Newton as he appeared to his contemporaries at the end of his life. In a further lecture delivered after tea by Lord Rayleigh, F.R.S., the work of Newton as an experimenter was emphasised, and some experiments were carried out. It was left to a third lecturer, Sir James Jeans, F.R.S., to deal with "Newton and the Science of To-day." Sir James said that the science of everyday life was still wholly Newtonian. We could not only be proud that the greatest of all scientists was our own countryman, but we could reflect with satisfaction that he was no freak genius or sport, but the concentrated embodiment of all the distinguishing characteristics of British science. During the meeting a small collection of Newton manuscripts, instruments, and other relics was arranged to be on view.

Defence Transportation in the U.S.A.—The U.S.A. Office of Defence Transportation has completed an investigation of freight traffic based on waybills collected from the railway companies. These waybills, numbering over 125,000, were coded, classified, and studied by a staff of fifty analysts, more than half of whom had been loaned by eleven different railways, and working with others from the Interstate Commerce Commission. The results of this study will be to give an accurate picture of the direction and flow of most commodities moving in the U.S.A., and will provide information as to how adjustments of freight service should be made in order to meet the increasing demands on transport.

Tribute to Sir George Usher.—Under the auspices of a committee consisting of Lord Nuffield, Lord Perry, Sir Felix Pole, Sir Patrick Hennessy, Mr. Garfield Weston, Mr. C. J. Bartlett, and Mr. A. A. Liardet, a dinner was recently held at Claridge's Hotel, at which Sir George Usher was the guest of honour. Lord Beaverbrook presided, and those present comprised a number of well-known personalities, including Lord Davidson, Admiral Sir Harold Brown, Sir Archibald Rowlands, Sir William Brown, Sir Charles Craven, Sir William Palmer, Sir William Letts, Sir Albert Stern, Sir William Crawford, Sir Roy Fedden, Dr. A. H. Railing. A tribute was paid to Sir George Usher's valuable service at the Ministries of Aircraft Production and Supply where he occupied respectively the positions of Director-General of Material Supply and Director-General of Tank Production. In his reply to Lord Beaverbrook, Sir George Usher expressed admiration for the dynamic energy of his lordship, under whom he served in both Ministries, and also expressed appreciation of the valuable work done by his Directors of Tank Supply—Messrs. Crozier, Cowley, and Dyer—and his thanks to the staffs in both Ministries.

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AFTER THE WAR

THE war had barely got into its stride before people began asking what we were fighting for. They demanded a definition of war aims. They wanted, perhaps, to know what they were going to get out of it. At best they deemed it unseemly to fight without an ideological motive. Many of them thought of the war less as a struggle with a dangerous enemy than as an historical episode that would lead to a new state of society in which their own political philosophy would be realised. Then came the long-drawn Battle of Britain, when the fight for our very existence overshadowed considerations about the purpose of the war. But through that grim and precarious struggle there were many who still saw visions of a time when the war had cleared away old traditional things and left a clear field for a new world order.

No longer does anyone ask, "What are we fighting for?" but thousands are wondering how we are to get the world rolling again when peace returns. Mr. Churchill, who has always preferred to concentrate on winning the war rather than on debating what is to happen when it has been won, referred in his broadcast speech on Sunday last to the possibility that an armistice may be signed in Europe before Japan is defeated, and added that in that case we should carry on our war efforts in the Pacific. Many people have felt that such a gradual ending of hostilities would be far, far better than sudden cessation all over the world, for it would give the nations time to readjust themselves to the changed conditions. It is not improbable that the Prime Minister referred to this possibility with the plans and planners of a new world expressly in mind. He may also have been thinking of them when he uttered a warning against expectation of an early and easy end to hostilities, and to the fact, patent to all, that we are busy planning the new world before we have got rid of the old one, and before we know all the details of the problem; for, as he said, "no one can possibly know what the state of Europe or of the world will be when the Nazi and Fascist tyrannies have been finally broken." Yet it must be agreed that everything cannot safely be left till the hour strikes. We must have some organisation ready to deal with the immediate problems that will face us, but no one out of a Fool's Paradise will think that plans made now for a new social order, a new industrial system, and a new financial system can be suddenly adopted; that we shall go to bed in the old order one night and wake up in the new order next day. One often hears the financial system or the industrial system spoken of as malign inventions which have been sprung upon a suffering world. Nothing could be further from the truth. Industrial and financial systems all over the world are the result of slow evolution; one thing leading to another, as new circumstances called for modifications and new events for new reactions. They are more truly a survival of the fittest than a spontaneous invention. Whether this slow evolutionary system can be supplanted, whether a world war gives man the opportunity for wiping the slate clean and reinstating only the good—if we can decide what it is—and rejecting the evil—if we can decide which it is—we shall not attempt to prophesy—but we have our suspicions.

We are writing at a moment when the Beveridge Report has just been circulated, when the National Policy for Industry (with its excellent introduction), signed by one hundred and twenty thoughtful men, a large proportion of them associated with engineering, is still fresh in our mind; on the eve of a special meeting of engineers, when their own particular problems will be discussed, and when Reconstruction is being debated in the House of Commons. These events are the outward symbols of a widespread, international feeling that the United Nations must have ready for use at a moment's notice, as it were, schemes for meeting the industrial and domestic problems that will follow demobilisation. But beside these very practical and necessary steps there is the more difficult problem of reconstructing the world on a new model. It is to be hoped that these two issues can be kept separate. For whilst the first may be attainable by agreement, the second will release forces difficult to control, and, as Mr. Churchill said, "the most painful experience would lie before us . . . if we fell to quarrelling about what we should do with our victory before that victory had been won."

Nomenclature

THE professional engineer has normally received a training which, in the lack of a precise definition, may be called scientific; and he should be able to speak with precision and use terms which are at least consistent; but, like the horse, "he does not always do so." Indeed, he is guilty of very loose nomenclature, as we shall show. The relatively youthful Institute of Cost and Works Accountants, realising the many pitfalls that are possible, has wisely prepared its own dictionary of costing, and has endeavoured to determine a standard nomenclature for costing generally, though whether it will succeed in killing without a chance of resurrection such terms as overheads, oncosts, and the like, remains to be proved. But the engineer, despite the labours of several committees, has made but little progress towards the removal of anomalies.

It seems ludicrous that the same word may be used with diametrically opposite meanings in different parts of the country. Take, for example, the word metal, which in the north is almost universally used with reference to cast iron, whereas in the south it implies brass or some form of alloy generically alluded to as yellow metal. The civil engineer will elevate his eyebrows and affirm that the correct definition of metal is the stones used for roadmaking, but the railway engineer will affirm with equal fervour that the word in the plural always conjures up in his mind a picture of the railway track itself; indeed, most of us probably use such expressions as "the locomotive left the metals," and these certainly are made neither of brass nor of cast iron. Again, is it necessary to have a number of variants for that humble tool the spanner? Who would care to have to explain the difference between it and the monkey wrench, although perhaps nowadays the latter usually refers to an adjustable spanner. There is something to be said in favour of a name perhaps least frequently applied, that of nut-key, which does at least clearly indicate its primary function. Let us now proceed to put the matter further to the test by showing the article to a military engineer, and he will reply without hesitation that it is an artillery tool. The word tool, like the engineer himself who uses it, finds itself used in a variety of ways, and we cannot but help feeling that speaking of a machine tool is not a particularly happy description when we also speak of the cutting agent in that machine tool as a tool. We still await a really comprehensive and exact definition of a machine tool. In the machine tool itself we find many anomalies, and we

could hardly select a better one than the loose headstock, which is frequently alluded to as the poppet head or, by those who are somewhat lazier, merely as the poppet. Others prefer to speak about the tailstock, reserving the appellation headstock exclusively for what the exponents of the loose headstock would designate the live headstock. Our choice is not exhausted, for the same article is known by many as the dead head, which an ordinary dictionary would define as a non-paying member. If it is necessary to have so rich a variety in our own country, it is hardly surprising to find ourselves at variance with current practice elsewhere. Just as we understand a billion to be a million million, while the American defines it as a thousand million, so when we speak of an 8in. lathe, the same machine tool across the Atlantic would be described as a 16in. lathe, so that many have cut the Gordian knot by always alluding to the lathe's swing rather than its centres. A standard set of taps numbers three, and some people are content logically to name them first, second, and third; but this system is too simple for others, who prefer other variants, such as taper, plug, bottoming, and the like. Even our spelling needs serious attention, as, apart from the tendency to adopt the more phonetic method of America, we can find no justification for some people to talk of a reamer while others always use the word rimer. Why the official spelling of the shell component should be fuze, when most dictionaries give it with an "s" is a mystery, but there are many good engineers who have misgivings as to the correct use of these two consonants.

Presumably we shall ever have to allow for dialects, brogues, and variations in pronunciation, but it is desirable to see that this should not lead to the evolution of entirely new words. Our vocabulary is increasing rapidly, new sciences, new inventions, even war itself, lead to the introduction of words unheard of before, but for that very reason we should be zealous in keeping this increase within reasonable bounds. To have one word and one alone for each article used by the engineer, and for that word to be the most appropriate of the many variants at present in everyday use, is an ideal, very desirable in some cases, but always likely to allow for variants dear to the heart of the philologist. The whole subject is a fruitful and entertaining study, and as baffling as it is charming.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PROGRESS AND INDUSTRIALISTS

SIR,—With all respect, may I be permitted to point out that your contention that the industrialist or other representing vested interests is no barrier to progress, is not borne out by the history of invention or even present-day experience?

Quoting Thurston's "History of the Steam Engine," an old work published in this country in 1883, Hancock, the most successful of the early inventors of the steam road carriage, in 1836 had a number of his vehicles in regular service in the London area, but they were eventually driven off the road "by hostile legislation procured by opposition interests." The author, however, admits that in this case the coming of the railway contributed, to which perhaps we to-day might add the absence of the pneumatic tyre, which at that date still lay in the womb of the future.

The railways themselves did not, however, escape the opposition of established interests, for, according to the same authority, the preliminary surveys for the Manchester and Liverpool Railway were conducted under great difficulty, "the surveyors being sometimes driven from their work by a mob armed with sticks and stones urged on by land proprietors and those interested in the lines of [horse] coaches on the highways."

That excellent play "Milestones," so popular in London several years ago, had for its theme the resistance to innovations in the shipbuilding industry, the builders of wooden ships opposing the introduction of iron, and in the next generation the builders of iron vessels opposing the introduction of steel.

You say also: "If the public wants something, or if the public can be persuaded to want something, it pays industry to provide it." But I suggest that you overlook the fact that the public cannot know whether it wants a thing or does not, until it is made aware of that thing's existence, which entails both demonstration and advertisement, and till the manufacturer consents to put it "in the shop window," no matter what advantages it may have, it must be content to blush unseen while the public passes by.

I could relate personal experiences of the last decade which prove beyond shadow of doubt that the inertia of vested interests is the greatest barrier to the adoption of any invention involving radical changes. I have, indeed, letters from manufacturers, both at home and abroad, that do not hesitate to state that while they approve the business offered, to associate themselves with it financially would prejudice their interests with other clients manufacturing rival plant. Can one need more convincing proof than this?

I agree, however, that a sound invention always emerges—in time. But to the inventor, a manufacturer possessed of vision, means facilities, and the enterprise to back his judgment, is as rare as a four-leaf clover. Both do exist, but are not easy to meet with.

Possibly the period of reconstruction ahead may smooth the path of invention not a little, though I fear I have small faith in the surrender of the profit motive, for, however little it may mean to the creative worker, it must ever be the mainspring of the commercial world, and even the creative worker desires to live.

November 28th. PATENTEE.

[We are pleased that our correspondent has noted that "a sound invention always emerges—in time." That is the gist of our contention. Opposition must be expected in early stages of invention, and in general is a healthy symptom, but, as the progress of road and rail locomotion shows, it is always overcome when the time is ripe.—ED., THE E.]

EDUCATION OF THE SONS OF ENGINEERS

SIR,—The letter of Sir John Dill in your issue of this week, November 20th, "The Education of Sons of Engineers," reminded me of a little book "Erewhon" (Butler), lent to me long ago in my youth by the gifted founder of THE ENGINEER—a little allegory, half humorous, half-cynical, that appealed to him as expressing the warning to engineers to which Sir Louis Beale's address to the American Society of Engineers, and your own impressive leaders on the subject have recently drawn attention—namely, to remember that the machine must remain man's servant and not be allowed to become his master. F. HOLMS

Kirkby Lonsdale, November 24th.

Sixty Years Ago

FORMING ALLOYS BY PRESSURE

THE beginnings of the modern science of powder metallurgy are to be found set forth in a short leading article, entitled "The Formation of Alloys by Pressure," which appeared in our issue of December 8th, 1882. The article was devoted mainly to a report of the results obtained by W. Spring on subjecting certain solid materials, including metals, to pressure, but without the application of heat. Spring found that bodies such as sulphur or yellow mercury iodide, possessing different allotropic forms, could be made by the application of very high pressure to them in powder form to pass from the form of lower density to the form of higher density. Similarly, a powdered mixture, say, of copper and sulphur, could be made to form a compound of higher density—copper sulphide—by applying great pressure to it in the absence of heat. Spring thereafter passed on to the formation of alloys by pressure. He prepared a mixture of coarse filings of bismuth, cadmium, and tin, in proportions corresponding to the composition of Wood's metal, and subjected the mixture to a pressure of 7500 atmospheres. The resulting block of material was reduced to powder by filing, and the filings were again compacted under the same pressure. The resulting block was apparently a true alloy, corresponding in all respects with Wood's metal, particularly as regards its melting point, which was 70 deg. A similar experiment with a mixture of lead, bismuth, and tin gave an alloy apparently identical with Rose's metal, which melts at 95 deg. A mixture of zinc and copper filings after being pressed, reduced, and repressed five or six times, gave a block exactly resembling brass, except that it was slightly darker in colour. That alloys could be formed purely by pressure had been suspected for some time. Romna, desiring to draw a very fine wire of platinum, had coated the wire in the first instance with electrically deposited silver, intending to dissolve the silver in nitric acid after the drawing process had been completed. He found that although platinum by itself is not attacked by nitric acid, the whole wire after being drawn was dissolved. The drawing pressure had caused the silver and platinum to unite into an alloy which was completely soluble. We noted that this result was in direct opposition to one reported by Dr. W. H. Wollaston in 1813. Wollaston succeeded in drawing a very fine platinum wire by enclosing it initially in a small cylinder of silver, and, after drawing, by dissolving the silver coating in nitric acid. We suggested that the difference in the results might in some way be due to the fact that Wollaston had applied the original silver coating in the form simply of a mechanical sleeve, whereas Romna had deposited it by galvanic action.

BOOKS RECEIVED

Fuel Testing. By G. W. Himus. London: Leonard Hill, Ltd., 17, Stratford Place. W.1. Price 21s. net.

Applied Electricity. By A. W. Hirst. London: Blackie and Son, Ltd., 50, Old Bailey, E.C.4. Price 15s. net.

Modern Synthetic Rubbers. By Harry Baron. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 25s. net.

Design of Machine Elements. By V. M. Faires. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 18s. net.

South African Mining Year Book, 1942–43. London: Argus South African Newspapers, Ltd., 85, Fleet Street, E.C.4. Price 21s. net.

Electricity Tariff Types. By D. J. Bolton. London: Chapman and Hall, Ltd., 11, Henrietta Street, Covent Garden, W.C.2. Price 5s. net.

Modern Oil Engine Practice. Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 30s. net.

Engineering Surveys: Elementary and Applied. By H. Rubey, G. E. Lommel, and M. Wesley Todd. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 20s. net.

Installing Power Factor Condensers

THE use of static condensers for improvement of power factor is becoming more and more widespread. It is a simple, efficient, and convenient way of reducing the wattless current component, and is one to be recommended. It does not appear to be generally realised, however, that a certain amount of care is necessary when specifying condensers to be connected in parallel with induction motors in order to avoid conditions which might result in either electrical or mechanical breakdown.

The writer has investigated a number of such cases recently, and the results make one wonder whether many breakdowns of motors and other plant have not really been due to the unsuspected condenser standing so silently in a corner.

Under circumstances to be described later it is possible for conditions to arise in which power factor correcting condensers may be responsible for the following troubles :—

(1) Mechanical damage to motor, transmission, or driven plant.
(2) Failure of insulation between line conductors and earth.
(3) Burning out of lamps or other single-phase apparatus.
(4) Flashing over or burning of fuses or switch contacts.
(5) Failure of condenser or motor insulation other than to earth.
(6) Difficulty in getting starter to hold in the " on " position.
(7) Melting of condenser fuses or rumbling and failure to exceed a certain critical speed when starting up.

It is well known that if an induction motor be driven above synchronous speed it becomes an induction generator, feeding power back into the mains. Its frequency is fixed by the mains, which continue to supply the necessary magnetising current.

It is an interesting fact, though not so well known, that induction machines can also generate when disconnected from any separate source of supply, if static condensers of suitable size are connected across their terminals to supply the wattless magnetising current. Under these conditions the generated frequency depends primarily on the speed at which the motor is driven. When excited by condensers an induction machine builds up its voltage in much the same way as a dynamo with the condensers in place of the shunt field, there having to be a little residual magnetism in the iron to start the building up process. Within limits the generated voltage depends on the size of the condenser, although obviously the machine cannot generate if the condenser is not large enough to supply its magnetising current or if the condenser is too large to respond to the comparatively small charges fed into it by the machine.

Where an induction motor has a power factor correcting condenser of suitable size connected across its terminals it is liable to act as an induction generator immediately after being switched off, and whilst it is slowing down or being driven by the momentum of any fly-wheel or machine which may be connected to it.

Some voltmeter tests were made on twenty-seven induction motors which had been in commission for some years. On fifteen of these the terminal volts rose to above mains voltage when the motor switch was opened, then gradually dropped as the machine slowed down. Naturally, where fly-wheels were fitted it took much longer for the voltage to fall to zero.

A simple test, requiring no instrument, is to open the isolating switch when the motor is running. If the machine is generating there will be a lapse of time before the starter trips owing to the generated voltage holding up the no-volt trip until the motor has nearly stopped.

In considering the seven troubles individually, the supply is taken as the standard 400-volt, three-phase, A.C. system, with earthed neutral, unless otherwise stated, and the machines are taken as having power factor correcting condensers connected of the required capacity to bring about the conditions described.

1. Mechanical Damage to Motor, Transmission, or Driven Plant

A 40 H.P., two-phase, squirrel-cage induction motor was direct coupled to a furnace blower and had a 15 kVA power factor correcting condenser connected to the stator terminals of the starter. The blower shaft fractured and another stronger one was fitted. This did not give trouble, but the motor shaft developed a twist of about 10 deg. within the 2in. of exposed keyway between the bearing and the coupling. The twist was in a backward direction, as if the motor had seized and the momentum of the driven fan had caused the twist.

The first theory was that the main circuit breaker had opened and that the machine had been driven as a condenser-excited induction generator by the momentum of the blower. The electrical load of the other apparatus connected being sufficient to bend the shaft. However, further investigation revealed a more feasible explanation as follows :—

An auto-transformer starter was employed, and as the handle was pushed over from " start " to " run " there was a pause, during which the free generated voltage became out of phase with the supply. When contact was remade in the " run " position there was sometimes a violent mechanical and electrical kick, depending on the relative magnitude and phase relation of the two waves at the moment the contacts touched. On the machine in question the trouble was aggravated by difficulty in getting the handle to hold on for the reason described later under (6). Consequently several attempts were necessary for each start.

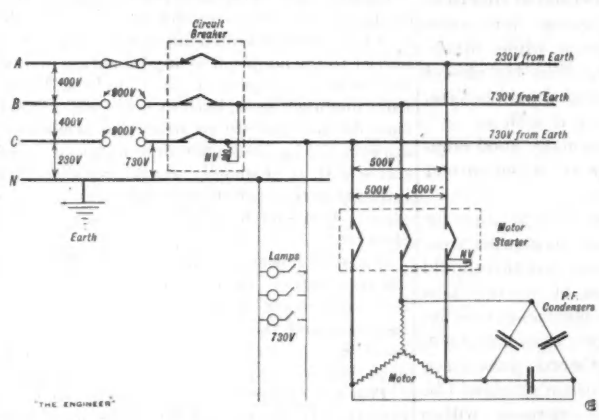

DIAGRAM OF CONNECTIONS OF MOTOR AND STARTER

A device was made with which to prove by practical tests what occurred when a motor with condensers was quickly switched off and on again to the supply, as with a two-position starter.

The device resembled a large centre-zero voltmeter with an extremely heavy pointer consisting of a balanced metal bar pivoted at its centre, the scale calibrated in degrees, and the pointer damped by friction, when desired. At each side of the pointer was a light needle to record the maximum deflection in that particular direction. The whole was mounted on the shaft of a 28 H.P., three-phase, slip-ring motor having a 15-kVA condenser, the motor running freely on ball bearings with no-load connected. The chief tests made were as follows :—

(*a*) The pointer was given a little spring pressure to return it to zero, and not much friction. The condensers were disconnected. On starting the motor normally and then allowing it to come to rest freely, a deflection of 18 deg. was recorded against rotation, due to the acceleration, and nothing with rotation. The same results were recorded when the switch was opened and closed again while the motor was running.

(*b*) With the pointer as before, and the condenser connected, a normal start and stop gave the same results. Opening and reclosing the switch, however, while the motor was running produced a kick in both directions, the deflection varied from 6 deg. to 56 deg. with rotation and was frequently right over the 90 deg. scale against rotation. No two attempts were the same.

(*c*) The friction was greatly increased so that a normal start only gave 1 deg. deflection. Opening and reclosing the switch always showed a kick both ways and always more against rotation, *i.e.*, tending to twist the shaft the opposite way to the twist on the 40 H.P. shaft. Owing to the increased friction the bar did not return to zero by spring force, so that when the motor came to rest the position of the bar indicated in which direction the last kick had occurred. This was always against rotation. In spite of the increased friction the deflection was sometimes over 50 deg. against and nearly 30 deg. with rotation.

(*d*) The friction was increased a lot more, making the bar so tight that the motor could be turned by it, and only the most violent kicks could move it. Under these conditions it was interesting to note that up to 10 deg. was recorded with rotation, but never anything against rotation. This, of course, corresponded with the damaged shaft referred to.

In recording the above tests over eighty readings were taken with various lengths of pause between opening and reclosing the switch. From the results it is evident that there are two distinct kicks ; first, one of short duration against rotation, which resembles a hammer blow and may be dangerously violent if the motor is rigidly coupled to its load, and particularly if the load has much momentum. This is followed by another kick in the opposite direction, which is less violent, but harder than anything likely to occur during a normal start.

When fortunate enough to remake contact with the two waves in suitable relationship there was practically no mechanical or electrical kick. At other times the motor gave a low-pitched grunt and sometimes a high-pitched. Sometimes the ammeter in line and stator circuits kicked hard over their 80-ampere scales. On one occasion the current in another similar motor connected from the same fuse board was noticed to double itself momentarily, due to the line disturbance.

Varying the amount of pause between opening and reclosing the switch did not produce any very conclusive results. If it were so long as to allow the motor to slow up considerably and the generated voltage to fall off, the kick was naturally less. Opening and reclosing as quickly as possible with a single movement sometimes recorded a big deflection, but as a rule was less noisy than after a longer pause. On this individual motor it happened that the worst kicks were recorded after about a second's pause.

2. Failure of Insulation between Line Conductors and Earth

In the event of two fuses melting or two phases opening for any other reason, leaving a motor and condenser connected by the third line only, a high breakdown voltage may result. Suppose, for instance, that under these conditions the machine generates 500 volts while remaining connected to one line. The voltage to earth on the two free phases back to the two melted fuses may reach a maximum of 500+230

=730 R.M.S. volts, which may prove too much for old or dirty insulation intended for 230 volts. (See diagram.) The frequency of the free generated voltage is below 50 cycles and is gradually falling as the motor slows up. It follows that the phase relation between the free voltage and the mains is constantly changing, the maximum voltage between line C and earth is when the mains 230 volts from N to A is in phase with the generated 500 volts between the free ends of lines A and C.

Owing to the generated power energising the no-volt coil, the starter does not trip.

In the case of a two-phase, three-wire system, if the neutral and one outer were to open, the voltage would probably rise to about 250 per cent. of normal.

3. Burning Out of Lamps or Other Single-phase Appliances

If the two melted fuses referred to above happened to be main fuses in a three-phase, four-wire system, having 230-volt lamps or other apparatus connected from neutral to one or both of the open lines, then the lamps, &c., would be subjected to about 730 volts, as shown in the figure, unless their load was sufficient to reduce the voltage. Obviously, this would immediately burn out the lamps.

The main circuit breaker, as well as the starter, would remain closed, due to the generated voltage.

4. Flashing-over of Fuses or Switch Contacts

Referring again to the diagram, in the same example the voltage across the fuse or contact which has broken will be even higher than the voltage to earth. As the phase relation changes there will be a time when the 400 volts opposes the free 500 volts directly, giving 900 volts, or 1270 peak volts, which would be dangerous.

If it was faulty switch contacts which opened the two phases, the high voltage would be likely to aggravate the sparking and burning by intermittently re-making contact.

In a case of a very heavy or high-speed flywheel, an alert attendant might conceivably reach to the fuse before the machine had slowed up, and so accidentally receive a shock of 1000 volts or more. This risk also exists in two-phase, three-wire systems, where neutral and one outer can become open-circuited.

5. Failure of Condenser or Motor Insulation other than to Earth

Normally the insulation between condenser plates, motor end connections, terminals, wiring, &c., should withstand the free generated voltage safely, but there will be exceptional cases where the voltage attained is higher than any the writer has tested. In such cases punctured insulation might result.

In the case of a 400-volt 59 H.P. motor tested, which had a star-delta starter and 30-kVA condenser, the voltage was 575 volts on switching off. If the supply had failed when starting up just before switching over to delta, there would be about 1000 volts between terminals, ends of windings, and wiring; the condenser, being star-connected, would only have 575 volts across its plates. This risk is not limited to three-phase supplies; it applies equally to any A.C. system.

6. Difficulty in Getting Starters to Hold On

Where the position starters, such as star-delta or auto-transformer types, are used with squirrel-cage motors, having overload trips without time lags, difficulty may be experienced in getting the handle to hold in the "run" position. This is due to the rush of current after the pause in neutral causing the overload trips to operate. Having once lifted, the overload plungers do not, as a rule, fall again, although the current becomes normal almost at once—see 1.

This applies to one and two-phase machines as well as three-phase.

7. Melting of Condenser Fuses or Rumbling and Failure to Exceed a Certain Critical Speed in Star Position

This concerns three-phase squirrel-cage motors with star-delta starters having the condensers in three banks, one across each winding phase—the standard practice.

The 59 H.P. motor referred to above is a good example of this condition; 40-ampere cartridge fuses were provided to protect the 30-kVA condenser, and these were found to melt repeatedly for no apparent reason. No fault was to be found on the motor or condenser tested separately. It was noticed that during the starting period, when the motor was nearly up to speed in star, a rumbling noise set in, accompanied by some vibration; the motor appeared unable to exceed this critical speed while in star.

On connecting meters in circuit, the following alarming values were observed as the critical speed was reached:—

Condenser current increased from 14·5 to 80 amperes in each bank.

Stator current rose from 6·6 to 90 amperes in each phase.

Line current rose from 8 to 32 amperes.

Voltage to star point rose from 230 to 500 volts.

Investigation revealed that similar conditions existed in several other machines on the same premises, and the phenomenon has since been met with elsewhere.

Various tests were carried out with different condenser sizes. It is not proposed to describe them in detail here, but the following outline may be of interest.

If the windings are star connected, and also the condensers separately, then at the critical speed a cable between the star points will carry a heavy current at a frequency approaching 150 cycles. As soon as the cable is open-circuited, conditions return to normal; the noise and excessive voltages and currents stop at once.

The star point becomes unstable at the one particular speed; excessive currents which then flow are more or less independent of the supply, and appear to be at the frequency which would be generated if the machine were being driven mechanically as a condenser excited generator at that particular speed.

When, then, does the trouble occur at one certain speed only? If the writer's theory is correct, it is the one speed at which resonance can occur between the condenser capacity and motor windings. As the motor accelerates, the frequency which it tends to generate also increases from zero to, say, 49 cycles. On the other hand, the resonant frequency of the internal circuit tends to decrease as the motor speeds up. It follows that there may be just one speed at which the generated frequency and natural frequency coincide. At that particular speed the tendency to generate is very much increased, so that the whole internal circuit becomes unstable.

This theory was partly borne out by connecting a larger condenser, thus decreasing the natural frequency, and, as expected, also reproducing this phenomenon at a lower motor speed.

Occasionally, there is a lucky start, when the motor runs past the critical speed without, as it were, being caught by the resonance. When, once this has occurred, it continues to run normally so long as it is not slowed down again by any means to the critical speed.

Some interesting oscillograph tests were made with a 15 H.P. slip-ring motor and various values of condenser capacity. These illustrated clearly the triple-frequency effect of the star point, and confirmed that it was three times the generator frequency and less than 150 cycles.

The three outer lines are, of course, held by the mains at almost a pure 400 volts, 50 cycles. This prevents the formation of a full-wave three-phase at, say, 45 cycles, which would otherwise be its tendency, but does not prevent the development of a triple frequency or third harmonic, each third peak of which forms 45 cycles with one particular outer terminal. The resultant of the three phases forms a pure triple-frequency, single-phase, heavy current, as was measured in the cable referred to between the two star points. Once a triple-pole flux is established in the iron, the three phases of the windings can be considered as three single-phase induction generators in phase with one another, each generating the third harmonic almost independently of the fundamental 45 cycles. In this form they are not hampered by being a balanced three-phase, and so can amplify and throw the star point out of stability as the three-phase fundamental cannot.

Conclusions and Remedies

It must not be thought from the above that the practice of connecting condensers to motor terminals is to be deprecated. Where the condenser is only intended to correct the power factor of the motor to which it is connected, it is unlikely that it will have sufficient capacity to supply the magnetising current, in which case there is no risk. It is more usual, however, for condensers to be connected to odd motors here and there in a works, so that each has to be large enough to correct the power factor of several machines.

As a rough general rule, one may say that unless driven above synchronous speed, a normal motor will not generate seriously, providing the condenser kilovolt-ampere is kept less than 25 per cent. of the motor horsepower. If a larger condenser has to be used, practical tests might be advisable. Perhaps a better rule is to keep the condenser current below, say, 30 per cent. of the motor magnetising current.

Where two-position starters are not employed there is perhaps no undue risk, so long as the generated voltage does not seriously exceed the line voltage; in that case condensers of about twice the size indicated in the previous paragraph can be used. It is better, however, to choose capacities which will not affect generation at all where two-position starters are used.

There is, of course, always the alternative of connecting the condensers to a distribution board, when discharge resistances and a separate switch will be needed. It can then be arranged that the motor fuses do not also carry the condenser current. In the event of the main fuses melting, however, the condenser might still cause the motor to generate if it happened that there was nothing else in circuit to absorb the power. This risk is usually negligible.

In the case of star-delta starters the risk of mechanical damage or resonance can be avoided by connecting the condensers permanently delta to the stator terminals A, B, and C, and providing discharge resistances. This method retains the advantage of using the motor starter to switch the condenser in and out of circuit, but the risks of electrical damage due to over-voltage remain.

If the only trouble to be overcome is difficulty in getting the starter to hold on—as per 6—then fitting time lag dashpots to the overload trips is to be recommended.

Referring to the danger of over-voltage—2, 3, 4—these risks can be greatly reduced by arranging for the circuit breaker or starter overload trips to operate before the fuses, so as always to break the three lines simultaneously.

"Shock Refrigeration."—A periodic cycle of cooling and heating is stated by the Westinghouse Company, of America, to be the best method of protecting expensive wool and fur flying suits from moths while they are stored between flights. The normal storage temperature is 35 deg. to 40 deg. Fah. In the "shock" cycle the temperature is reduced to 15 deg. Fah. for several days to kill any larva which may be feeding. Then, by cutting off the refrigeration and introducing heat—usually from strip heaters in the supply duct or coil chamber—the storage room temperature is quickly raised to 50 deg. Fah., at which value it is held for a few hours only. This causes any surviving larva again to become active and will hatch out any potentially dangerous eggs. The temperature is then suddenly dropped to 15 deg. Fah. for a day to kill off the surviving larva and any larva newly hatched. After one day at 15 deg. Fah. the temperature is brought back to the normal value. This procedure is repeated at regular intervals or, to prevent reinfestation, when any appreciable quantity of untreated articles of clothing is placed in the storage room. Relative humidity is high enough to prevent drying and cracking of the fur skin, but low enough to prevent mould or mildew. During the normal storage period with temperatures of 35 deg. to 40 deg. Fah., the relative humidity is about 50 to 65 per cent.

Railcar Oil Engines in the Argentine*

By C. R. PARKER

(*Continued from page 439, November 27th*)

Ball Bearings.—The following parts run on ball bearings :—

(1) Oil pump intermediate driving gear.
(2) Governor and water pump spindle.
(3) Fuel pump intermediate driving shaft.
(4) Fuel pump camshaft.
(5) Intermediate timing gears.
(6) Valve rocker arms.

With the exception of the last two locations, the ball bearings have given continuous trouble, complete collapse sometimes occurring after only 30,000 kiloms. of service. Better results were obtained in some cases than in others, but a renewal at partial overhaul was always necessary. All likely causes of this trouble were investigated, lubrication was checked and shafts balanced as well as possible, but without results. The housings were then modified to accommodate the largest and heaviest duty bearings that space would permit, but the results were still unsatisfactory, with the exception of the fuel pump camshaft bearings, when double roller bearings gave the desired degree of reliability. After this experience it was decided to replace the ball bearings with floating bushes wherever possible. Up to the present only the oil pump intermediate driving gear and the governor and water pump spindle have been dealt with, these details having given the most trouble.

The governor spindle has been provided with a coupling in order to avoid changing the whole shaft for wear at the pump glands. This was necessary with the original arrangement. The coupling can be seen in Fig. 24. The fuel pump intermediate driving shaft will be similarly fitted with floating bush bearings as soon as circumstances permit.

Trials were first carried out with the bearings shown in Fig. 25. After 109,000 kiloms. of service no wear whatever could be detected in any part. Trials with the governor bearings are not yet completed. Quite apart from improved reliability, floating bushes are an advantage in that they are easily maintained and manufactured. Furthermore, should failure occur, the damage will be less, as there are no broken balls, &c., to lodge in any gear teeth that may be in the vicinity. Fig. 25 shows a section of the floating bush arrangement for the oil pump intermediate driving gear, and Fig. 24 that for the governor and water pump spindle.

Camshafts and Followers.—Cams are renewed on condition. Surface cracking was at first common, and is now less frequent. The alignment of the following rollers to the cams is important, as inclination will cause the camshaft to slide into cold starting position (delayed air valve opening), which produces valve clatter and the possible breakage of the valve stem ends. Fig. 26 shows a simple device made from scrap material for pressing on and withdrawing cams. Camshaft bearings, follower rollers, guides, tappets, and push rods give trouble-free service, and are renewed on condition. As the cam seats are the same diameter as the journals, scoring occasionally took place as the cams were being withdrawn. As the camshaft bearings are renewed, this defect is being overcome by slightly reducing the diameter of the journals. The timing gears have given no trouble, except in cases where parts of broken ball bearings have lodged in the teeth.

Lubricating Oil Pumps and Piping.—Oil pump bushes are renewed at every general overhaul. The gears have stood up well, and so far renewal has not been necessary. They were originally made solid with the shafts, but have since been modified to enable new shafts to be fitted to the existing gears. The internal oil piping causes considerable inconvenience during overhaul, as it has numerous joints that are difficult to make oil-tight. In view of its importance, the piping is subjected to a pressure test of 25 kilos. per square centimetre before being passed into service. Fig. 27 shows an oil pump, with its piping, &c., in the foreground, from which the unsatisfactory nature of the arrangement will be appreciated. Welding the pipes in position is not possible, owing to the crank cases being of light alloy.

A combined oil cooler and fine filter cooled by jacket water is located on the side of the engine. A by-pass valve maintains the bearing feeds if the filter elements choke or fail to pass sufficient oil when cold. A section of this valve is shown in Fig. 28. The seat-locking screw and pin to prevent the ball from being lost in the cooler when the spring is removed have been fitted, as considerable trouble was experienced, particularly with the seat screwing out and preventing the valve from lifting. It is believed that this small defect, in restricting the oil supply, has been responsible for a number of big-end failures.

A protective device to shut down the engine in case of loss of oil pressure was originally supplied with each unit. These were under constant attention by the makers, but were eventually removed as they proved unsatisfactory. The apparatus was ingenious and designed to operate in the case of pressure failure or fused bearings. Variations in oil pressure due to different engine speeds and changes in oil viscosity due to temperature made the apparatus behave irregularly and caused many delays in service. Simple pressure contacts arranged to give the driver warning of reduced pressure were also fitted, which functioned satisfactorily. Protection is dependent on the human element, and unfortunately the contacts have to be set to operate at a pressure below that which will cause big-end trouble under load. The relays operate when the pressure falls to 1·0 kilos. per square centimetre. This was increased to 3 kilos. per square centimetre for trial, but at this setting

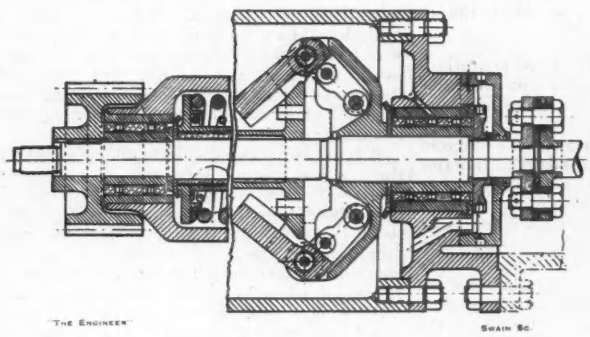

FIG. 24—*Section of Floating Bush Bearings for Governor and Water Pump Spindle*

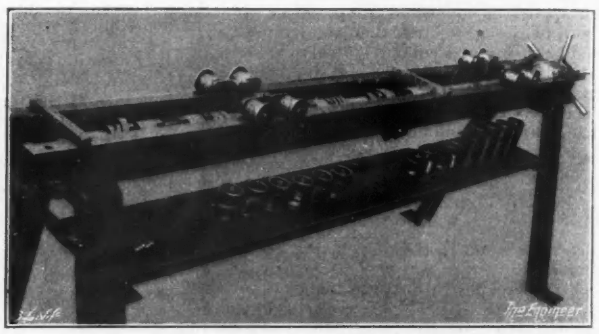

FIG. 26—*Device for Pressing-on and Withdrawing Cams*

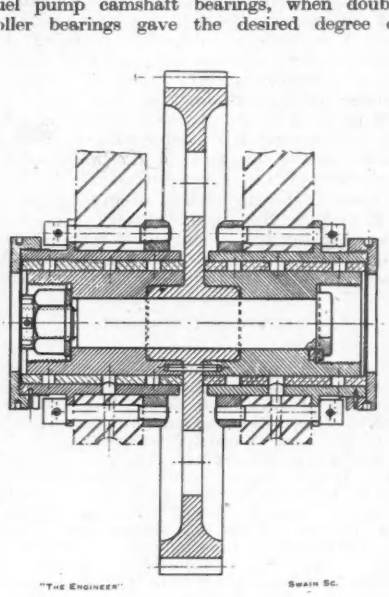

FIG. 25—*Section of Floating Bush Bearings for Oil Pump Intermediate Driving Gear*

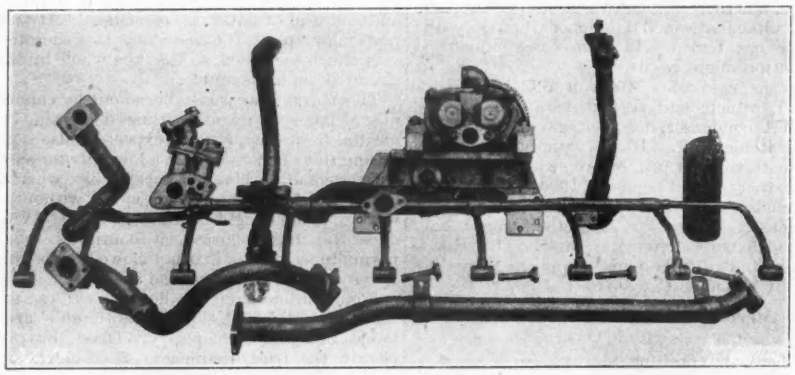

FIG. 27—*View of Lubricating Oil Pump and Piping*

* Joint meeting, Diesel Engine Users Association and Institution of Locomotive Engineers, November 5th, 1942.—Abstract.

the danger indications given with hot oil at low engine speeds induced the drivers to ignore the warnings. It will be appreciated that protective devices depending on the human element leave much to be desired, but when discretion also is necessary, such devices are worse than useless. Circumstances have not permitted the development of a reliable device to guard against trouble from low oil pressure, but such an apparatus is very necessary and is being considered.

The main feed pipe from the oil pump is fitted with a relief valve set to lift at a pressure

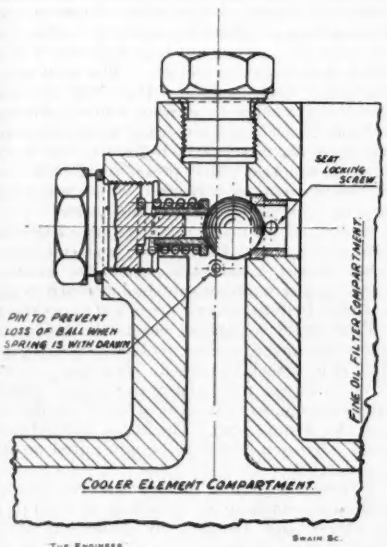
SEAT LOCKING SCREW
PIN TO PREVENT LOSS OF BALL WHEN SPRING IS WITH DRAWN
FINE OIL FILTER COMPARTMENT
COOLER ELEMENT COMPARTMENT
"THE ENGINEER"
SWAIN SC.

FIG. 28—*Oil Filter By-pass Valve*

of 15 kilos. per square centimetre. The valve gives no trouble, but is of insufficient capacity to relieve excess pressure when starting from cold. Many pipe joints have burst, and it is probable that this defect has contributed to some extent to the failures of the ball bearings carrying the oil pump intermediate driving gear. Redesign of the relief valve is now being considered, and it will be made sufficiently large to be able to handle the full pump output under all conditions, the maximum pressure being limited to 6 kilos. per square centimetre.

Fuel Pumps and Injectors.—With the exception of the bearings previously mentioned,

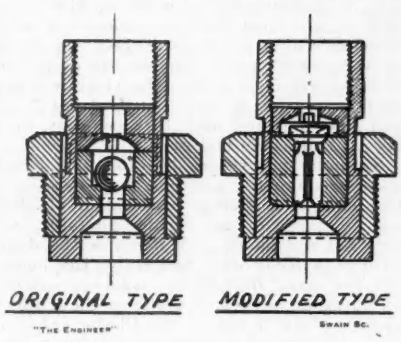

FIG. 29—*Fuel Pump Delivery Valve*

renewal of the principal parts due to wear has not been necessary. The plungers and barrels are almost as new, and as most of them have already reached 500,000 kiloms. in service, an exceptionally long life is anticipated. The plungers are free from helical grooves, &c., with their associated sharp edges, which appears to be an advantage, as other types of pump lose accuracy due to wear in the vicinity of these grooves. The suction valves in the plunger ends have given no trouble whatever, but the delivery valves have been redesigned, because the original ball type caused misfiring due to the rapid wear of the valve seats. Sections of this valve are shown in Fig. 29. It was found, however, during the period that the mitre-seated valves were under trial, that better hardening of the original type of seat gave good results, and the valves would stand up to the full period between general overhauls without regrinding the seats.

Trouble has been experienced due to the control wedge guides cracking, and in one particular case the control rod was jammed by two pieces of the guide which overspeeded the engine to destruction. The cracking of the wedges has also occurred, but without consequential damage. The trouble is believed to have originated during the hardening process. Case-hardened mild steel gives good results.

The fuel pumps are thoroughly cleaned and readjusted at each overhaul, the rollers, pins, bushes, &c., being renewed on condition. Injection springs are adjusted to give a pressure of 280 kilos. per square centimetre, and the individual pump strokes are balanced. Calibrating equipment as used for other types of pumps in service has been considered, but up to the present the accurate adjustment of the plunger travels has given satisfactory results. It has been found necessary, however, to readjust the plunger strokes at least twice during the engine tests, before the settings will remain constant. As the fuel pump is driven through a "free-wheel," it can be turned in normal direction of rotation without barring the engine round, thus greatly facilitating quick adjustment.

Fuel Injectors.—The fuel injectors give little trouble beyond the occasional breakage of the valve springs. Fig. 30 shows the section of a complete injector. Spring breakages always occur at the loop for attachment to the valve, and although the cause of the failure has not been definitely proved, it is believed that leakage at the valve seat sets up a vibration of sufficient magnitude to cause the spring to fail through fatigue at its weakest point. All springs are carefully calibrated and valves lapped in

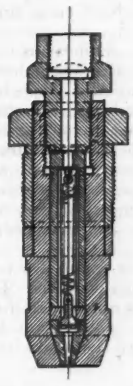

FIG. 30—*Fuel Injector*

radiating from the centre hole are not considered dangerous, but in all cases where cracks run towards each other, the combustion chambers are scrapped. Although a lot can be said in favour of a direct injection system, and, indeed, the author believes it will become universal with the introduction of pressure charging, this does not alter the fact that the Ganz Jendrassik system on the self-aspirating engines in question has given excellent results. One important fact from the overseas users' point of view at present is that the design of injectors and fuel pumps, &c., is such that spares can readily be manufactured locally.

Governor and Water Pump.—The governor and water pump form one unit driven from the timing gear train. The whole arrangement has been a constant source of trouble, the bearings failing frequently, as previously mentioned. The spindles wear quickly at the water pump glands and leakage is difficult to prevent. The fly-weight pins and rollers are far too fragile for the service required. Renewable hard steel bushes have been fitted where possible, and a coupling introduced to enable the water pump spindle to be renewed, without upsetting the whole governor arrangement (Fig. 24). Each unit is given a complete overhaul when the engines are shopped.

Piping.—Water pipe joints of the hose and

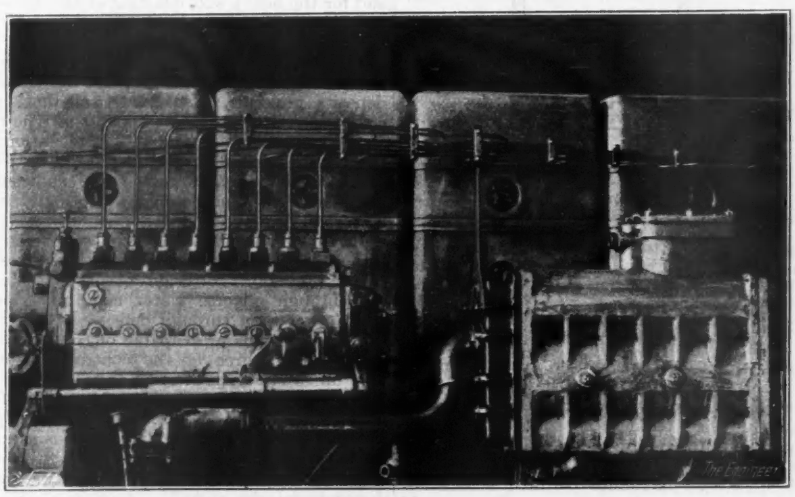

FIG. 31—*Modified Injector Pipe Arrangement*

during overhaul. In service, the injectors run about 30,000 kiloms. without requiring cleaning.

The injector pipes, which are all the same length, have their surplus length coiled. These pipes occasionally gave trouble through coming into contact with push rods and studs, &c. Arranging the pipes in the manner shown in Fig. 31 has eliminated this trouble. Brazing leaky tubes and unions has proved very satisfactory.

Combustion Chambers.—Fracture of the combustion chambers was frequent when the engines were first put into service. Pieces breaking out would foul the piston crowns, jam under the valve seats, and cause trouble generally. Retarding the point of injection from 23·5 deg. to 21 deg. B.T.D.C. proved the remedy, and failures are now remarkably few. Slight cracking and burning still occurs, but in the majority of cases the combustion chambers will last more than the established period between general overhaul. Fig. 32 shows the combustion chamber details. The combustion chambers are changed on condition. Cracks

clip type have given a great deal of trouble, and are located in very inaccessible positions. Leakage fuel and lubricating oil falls on these, causing rapid deterioration of the rubber. These joints have been eliminated, with the exception of one inlet and one outlet to each cylinder head, and by suitable protection against oil, the hoses will last the period between partial overhauls. No suitable provision was made in the cylinder heads for the drainage of grease and lubricating oil from the rocker gear and leakage fuel oil, with the result that the engines being bogie mounted were very soon in a filthy state. Drainage is now being arranged so that all leakage will be collected in a small deposit.

Engine Testing.—As previously mentioned, the thorough testing, running in, and tuning up of all engines after overhaul has proved vital to ensure reliability in service. After general overhaul, engines are run for 60 hours for running in and tuning up, with a final 8 hours' continuous run on full load. Cylinders are lifted and rings and heads inspected and cleaned after 35 hours' running. Big ends are examined

for temperature and clearance during the first few hours, after which they receive no further attention. Originally the big ends were dismantled when the pistons were examined, and any high spots removed, according to the maker's recommendations. This was discontinued when fine boring was introduced. Complete test logs are made up and for convenient reference the final 4 hours' run and other points likely to be required are recorded on a small form.

After partial overhaul the engines are run for approximately 20 hours, including 4 hours on full load. The pistons are not inspected. Test plates, supports, couplings, weighing machines, water brakes, and other small testing facilities have all been made in the railway company's workshops, utilising scrap and surplus material. The original water brake was purchased from the engine builders, and the tachometers, pyrometers, &c., from other sources.

Up to the present, the water supply for testing has been taken from the works mains. This was considered undesirable, as quite apart from the heavy consumption, the water is of bad quality and serious scaling of the brake took

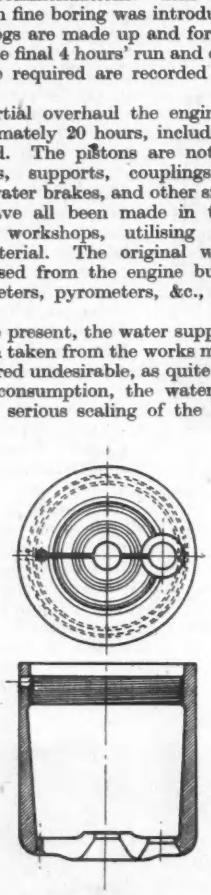

FIG. 32—*Section of Pre-combustion Chamber*

place. A cooling tower is now in the course of construction, and good quality make-up water will be drawn from the tanks of locomotive tenders entering for repairs.

Financial conditions prevented the purchase of a cathode ray indicator for test bed use. Had such an instrument been available, many of the test problems would have been solved more quickly and with more certainty, particularly when testing the suitability of fuel oils, tracing fuel pump defects, finding a cause for connecting-rod failures, or, when trying to determine the maximum permissible wear of injector holes, &c. Indicating apparatus would also have been of great utility in training the staff. A good indicator demonstration saves weeks of labour in this respect, and for this purpose alone the apparatus could be a good investment. In the author's opinion, suitable indicators should be included in any overseas specification involving engines larger than the road vehicle type. All fittings should be supplied by the engine builders.

Records of Wear.—Details of wear and notes of importance and any parts changed, &c., are recorded on a special form at each general overhaul. By this means the complete history of every engine and its component parts can be readily obtained. This arrangement has proved very satisfactory, and particularly helpful at the present time when nearly all the engines have some locally made part or substitute on trial.

Drawings and Spare Part Design.—Detail drawings of every engine part have been prepared, and in the case of consumable spares, these are designed for stock with working or fitting surfaces left to be finished as required. For the majority of parts the drawings take the form of the railway company's standard "Regulation Drawings," measuring 12in. by 10in., and include all information as to the material, where obtained, catalogue prefix number, &c., which enables the stores department to maintain stocks on a basis of the estimated annual consumption. The maintenance of adequate stocks of spare parts by the stores department is of vital importance, and for this reason close contact between the engineering and stores staff is essential.

(To be continued)

Corrosion of Boiler Tubes*

By T. HENRY TURNER, M.Sc.†

(Continued from page 448, November 27th)

PREVENTION OF CORROSION

General.—The foregoing sections of the paper have been based on locomotive practice. The lessons learned may in some cases also help to increase the life of tubes used in marine boilers and stationary boilers.

The author believes that whatever the true theoretical explanations may be of the various types of cracks which occur in boilers, many, if not all, of the cracks could be avoided if engineers would round off sharp edges and leave the surface of the metal in a state of compression. Cracks grow when opened out in tension. If the surface of the steel is put into a state of compression by, for example, heavy shot-blasting, the fatigue strength of the surface is increased, pores are closed up, and sharp edges are rounded off.

If boiler plates, after bending and drilling, were heavily shot-blasted, especially round drilled holes, very little would be heard about caustic or other cracking.

It thus appears that a good case can be made out both for the light shot-blasting of tubes and for the heavy shot-blasting of the inside of a boiler shell, particularly near holes, before riveting up.

The general rule seems to be that to prevent corrosion the water must be made such that it deposits no scale, is definitely alkaline, and contains as little oxygen as possible. The prevention of corrosion and the prevention of boiler scale formation are inseparable in practice. Fortunately, waters made sufficiently alkaline to be non-scaling are normally non-corrosive.

In George Stephenson's type of locomotive boiler certainly, and in many other types of boiler probably, corrosion occurs and tubes fail through adverse water conditions much more often than through defects in the steel. Water conditions are capable of control. The nature and degree of the control will vary according to the type of boiler and feed water.

Locomotive boilers may take many feed waters, and normally use 100 per cent. raw water and no distillate. They are controlled by different crews from day to day. Stopping, starting, and hill climbing make widely varying demands on the steaming capacities of such boilers from minute to minute.

Marine boilers use mainly distillate, with but little fresh water make-up, and are normally under the control of the same skilled engineer. A steady output of steam is often maintained for long periods without many sudden changes.

Stationary boilers generally have only one feed-water supply, but that may vary from time to time. It ranges from the almost 100 per cent. distillate of power houses to the almost 100 per cent. fresh water make-up where the boilers supply works or process steam.

The approach to the problem of how to prevent corrosion of boiler tubes will be helped if these three classes of boilers are considered separately.

Locomotive Boilers.—A locomotive boiler shell outlives several sets of tubes. In bad water districts tubes formerly had to be shifted or changed entirely at the running sheds between major repairs. The installation of water softeners frequently made it possible to run from shop to shop without changing any tubes. The author's own experience has shown that so little repair was needed to the boilers, after some years of softened feed water, that they were no longer removed from the frames when the engines were returned to the works for general repairs. For that reason the emphasis in the present paper is on tube corrosion rather than on general boiler corrosion.

The cause of and remedy for pitting and corrosion of locomotive boiler tubes and sheets, with special reference to the status of embrittlement investigation, has been the subject of a series of reports by R. E. Coughlan,† Schroeder‡ and others, who state that about 500 locomotive boilers are known to have suffered intercrystalline cracking in service on American railways.

Similar trouble has not been reported in locomotive boilers in this country. The most recent American work suggests that the chemical aspect of the subject has been over-emphasised, and that British engineers may in some measure attribute their relative immunity to better riveting practice. The problem of protecting idle boilers against corrosion, which was necessary in the slump,§ does not now arise.

Almost all locomotive boilers are of the fire-tube type. Steel tubes have replaced copper tubes almost universally; but the arsenical copper fire-box remains in the locomotives used in Great Britain, except for a few experiments.

Feed water sometimes enters the boiler well below the surface and so evolves its gases where they may attack the steel. In better practice, it is admitted near the water-steam surface, into a trough, so that most of the gases flash off into the steam space. The latter method saves much corrosion and is to be advocated on that account.

External softening of feed waters saves the premature blocking up of preheaters, feed pipes, injectors, and troughs by baked-on sludge derived from the temporary hardness. It also removes part of the dissolved carbon dioxide by precipitation in lime/soda softeners as calcium carbonate. This process also appreciably reduces the amount of salts which actually enter the boiler and so helps to reduce corrosion, scale, and priming. The use of the base-exchange process of softening causes much corrosion unless it is carefully controlled and coupled with additions of caustic soda and tannin. Filling up with raw water after washing out the boiler or changing the water promotes corrosion and priming.

It must be remembered in this connection that locomotive boilers are outstanding in the amount of water which they evaporate; 11·5–12·5 lb. of water is evaporated hourly per square foot of surface exposed to water, and, or alternatively to, steam in the boiler. This is more than twice the amount of water evaporated by some Lancashire boilers, and even by water-tube types. Moreover, the proportion of steam-wet area to the total steam-wet and water-wet areas is very small—4·0–4·7 per cent., as compared with 16·8 per cent. for a typical Lancashire boiler.

Naturally soft waters are often acid. Such waters require the addition, in proportion to the number of gallons evaporated, of alkali and, if possible, an organic inhibitor, *e.g.*, soda ash and tannin. To minimise the sludge formed in locomotive boilers by the normal 100 per cent. fresh-water make-up, external softeners are advocated wherever the hardness exceeds about 5 deg. on the Clarke scale. In service during recent years water softeners have greatly reduced the wastage of tubes in certain London and North-Eastern Railway boilers. Many more softeners are needed for locomotive feed waters in Great Britain, and much improved designs are now available.

* Institution of Mechanical Engineers, November 20th, 1942. Abstract.

† Chief chemist and metallurgist, London and North-Eastern Railway Company.

† See reports by R. E. Coughlan and others in Bulletins of American Railway Engineers' Association: 1938, Vol. 40, page 73, Bulletin No. 404; 1938, Vol. 40, page 222, Bulletin No. 707; 1939, Vol. 41, page 214, Bulletin No. 414; 1940, Vol. 42, page 96, Bulletin, 421, "Cause and Remedy for Pitting and Corrosion of Locomotive Boiler Tubes and Sheets, with Special Reference to Status of Embrittlement Investigation."

‡ Schroeder, W. C., Berk, A. A., and O'Brien, R. A., 1940, Report of Association of American Railroads on "Intercrystalline Cracks in Locomotive Boilers"; see also *Railway Age*, 1940, Vol. 109, page 25.

§ Morrison, J. P., 1936, *Boiler Maker and Plate Fabricator*, Vol. 36, page 246 (see also *Modern Power and Engineering*, 1936, Vol. 30, page 26), "Protecting Idle Boilers Against Corrosion."

Abnormal corrosion, both of steel tubes and fire-box copper, has been associated with unusually high amounts of dissolved salts in some cases, and it is clear that locomotive engineers often do not blow down and change the water as much as is desirable to prevent corrosion. Control by chemical tests is the wisest method of keeping the salt concentration at a safe low figure. In present practice, this figure seems to be between 150 and 220 grains per gallon of dissolved salts, but the ratio of alkali to total salts is important. The American Railroad Engineers' Association recommend a proportion of caustic soda of 10 per cent. or caustic soda plus sodium carbonate of 15 to 20 per cent. of the total dissolved solids, and this seems to be good advice.

Marine Boilers.—Water-tube boilers and fire-tube boilers are both used on board ship, but, from the point of view of increasing the life of the boiler tubes, they are best classified under the following groups, according to their type of feed water. Marine boilers are mainly fed with condensate. The small make-up may be classified into the following groups :—

(1) Sea water untreated.
(2) Sea water distillate.
(3) "Fresh" water untreated.
(4) "Fresh" water which has been softened by means of a plant aboard ship.
(5) "Fresh" water distillate.

Method of Treatment : Group (1).—No satisfactory method has yet been developed for the chemical treatment of raw sea water.

Groups (2) *and* (5).—This feed water make-up is practically pure distilled water. The small amount of contamination should be dealt with by a mixture of suitable chemicals added to the feed water. The liming of boiler waters may have been retained as a so-called practical expedient. It must not be regarded as fit to be retained in modern boiler operation at higher pressures. It leaves an incomplete coating on the boiler surfaces which does not prevent pitting but does aid overheating of the steel. Soda ash and tannin mixtures are used successfully in many low-pressure stationary boilers having a fairly high percentage of make-up. Their use aboard ship is much more rare, because of the somewhat higher pressures and smaller amount of make-up. Soda ash must therefore be supplemented by sodium phosphate, and starch replaces tannin, as the latter is not always suitable where the ingress of oil cannot be prevented. Starch helps to eliminate oil ; so disodium phosphate, sodium carbonate, and starch mixture is to be recommended. This mixture was developed as B.P. No. 451,929 from the well-known "U.S. Navy Boiler Compound 1933." It has given results which justify its wider use for marine boiler systems using water of this type.

Group (3).—"Fresh" water supplies vary from port to port, but the amount of fresh water used as make-up is relatively small. In many cases the normal mixture mentioned above, B.P. No. 451,929, is satisfactory for waters of this type, but where the temporary hardness forms a relatively high proportion of the total hardness of the "fresh" water, the sodium carbonate might require variation. Any such variation should be made according to the results of tests of the boiler water carried out to methods available in text-books on boiler water treatment. Such tests are not beyond the capabilities of engineering staffs aboard ship as a normal routine.

Group (4).—In general, the treatment for this group would be the same as for group (3), except that the amount of treatment would be considerably less, owing to the much lower hardness of the feed water, but allowance would have to be made for the alkalinity present in the softened water. Routine tests on the boiler water samples would readily facilitate the necessary adjustments of the chemical dosages and of the proportions of the constituents of the mixture.

Chemicals Required.—Whilst in land boiler practice a fairly wide range of chemicals is used in water treatment, the foregoing consideration has shown that for the treatment of feed water for marine boilers, the only chemicals really necessary are sodium carbonate, sodium phosphate, and starch. Sodium carbonate hydrolises in a steam boiler partly to caustic soda. This mixture therefore provides the necessary chemicals for a complete precipitation of the calcium as phosphate and magnesium as hydroxide in the boiler. The starch coagulates these precipitates and any oil which may be present in the feed water, and prevents the precipitates from adhering to the heat transfer surfaces. The treatment is carried out to a sufficiently excessive extent to ensure the presence in the boiler of enough sodium carbonate, sodium hydroxide, and sodium phosphate to prevent corrosion, provided that the water is free from oxygen. In the majority of marine boiler installations the feed water is practically deaerated, but in the absence of effective deaeration it may be necessary to use either sodium sulphite or tannin, if oil is absent. All the above-mentioned chemicals are expected to be in reasonable supply, especially for priority purposes.

Technical Training.—The marine engineer must be more self-reliant than his colleague on shore, who can call in consultants when required. As the whole functioning of the ship depends upon the correct treatment of the boiler water, it would seem reasonable for the authorities concerned to send all marine boiler engineers to brief specialised courses of instruction in boiler water control, in the same way that men have for many years been sent to brief courses on gunnery and similar subjects.

One suspects that it might be difficult to find many men fit to instruct marine engineers in boiler water control. Yet the losses due to corrosion prove the need for the use of improved knowledge. Such courses are certainly required for naval and mercantile marine engineers. Their knowledge, when they retire to shore jobs, would then become available to land engineers, and would be of particular value.

The most recent American bulletin on caustic embrittlement does not offer any substantial support for the belief that sodium sulphate will prevent caustic embrittlement. The belief that tannin and other materials act as inhibitors is also not backed with as much long-time experience as one would desire.

No case of embrittlement has been recorded from over 500 vessels containing from one to sixteen boilers, in which the alkalinity was held between approximately 40 and 300 parts per million, according to Schroeder and Berk's recent summary of experience in the U.S. Navy.

The present trend of thought seems to be in the direction of laying the blame for caustic embrittlement on the inferior riveting of seams, and bad tube-fitting practice permitting leaks by strained steel. In the case of seams the leaks, fortunately, often give timely warning of the development of caustic cracking.‖

Stationary Boilers : (1) *Hot-water Boilers.*—Before considering the prevention of corrosion in steam-raising boilers, a few comments should be made on the steel and cast iron boilers which are widely used for producing hot water at atmospheric pressure. These sometimes corrode rapidly, as does the piping of the hot water heating system, or the hot water supply service to which they are connected.

With hard waters, scale forms in any such boiler and the metal overheats if there is a constant large draw-off and make-up. With naturally soft waters, corrosion occurs under the same conditions. Calorifiers should be used in either case. The resulting closed circuit requires little make-up and causes little corrosion of the boiler, the water of which could be treated with soda ash and tannin if desired. Base-exchange softened waters will still corrode the hot water supply pipes from the calorifier, but that is usually cured by by-passing unsoftened water to give a hard water mixture in the supply services, the hardness being 5–8 grains per gallon.

The way in which carbon dioxide and oxygen dissolve in condensate, and the investigation of practical means for keeping water free from these corrosive gases, has been the subject of a special study by a committee of the American Society of Heating and Ventilating Engineers.

(2) *Low-pressure Steam Boilers* (80–160 *lb. per square inch*).—A considerable experience of vertical, locomotive, and Lancashire type stationary boilers has shown that many are working without any boiler water conditioning treatment. Scale thus accumulates, and periodical descaling causes the boiler to be out of service for several days each year. Serious corrosion has been noted in several districts where impure river waters or naturally very soft moorland waters are used as feed.

Scale and corrosion troubles are both minimised by controlled additions of soda ash and tannin, care being taken, of course, to avoid conditions thought to cause caustic embrittlement. Many hundreds of pounds have been saved in boiler maintenance in this manner. Chemical control of the boiler water and proper adherence to blow-down schedules are necessary, however.

(3) *Medium-pressure Boilers* (160–250 *lb. per square inch*).—These water-tube boilers are given greater attention by the engineers in charge. In many cases their feed water make-up is softened, and they normally work with a scale only as thick as an eggshell. Bulging of the tubes would occur with thicker deposits. The worst corrosion here seems to arise in the cast iron feed-water heaters when complete deaeration is not practised. The corrosion of the preheater saves the boiler tubes by using up some of the oxygen, and the cast iron of the preheater is thus caused to act as an unofficial deaerator. Leakage of condensers is a source of boiler trouble, especially when dock or canal waters are used as cooling waters. Treatment here would be similar to that recommended for marine boilers—groups (2) and (5) above.

(4) *High-pressure Boilers* (600 *lb. per square inch*).—The authorities in charge of the high-pressure boilers used in the best-run modern power houses employ chemists and maintain the closest control of boiler water conditions. It would be out of place therefore to say much about this control, other than that it is an example which deserves to be followed in many respects by those in charge of other types of boilers.

High-pressure boilers require a feed water of very high purity. Its adherence to that standard must be controlled with the minutest care throughout the whole working life of the boiler. The following standard of purity is said¶ to have proved satisfactory and is not difficult to attain in a well-designed closed-feed system :—

Oxygen not exceeding 0·01 millilitre per litre of water (compare this with 6·6 millilitres of oxygen per litre for most natural waters). Electrical conductivity not due to ammonia, not exceeding 1 microhm per cubic centimetre at 20 deg. Cent., hydrogen ion (pH) value in the absence of ammonia, slightly alkaline, *e.g.*, 7·3–7·5 at 20 deg. Cent.

RECOMMENDATIONS

The following recommendations are based on experience with locomotive type boilers, but may have a wider application.

(*a*) *Steel.*—(1) Specify new tubes to have scale-free, pickled, or shot-blasted surfaces, and to contain 0·2–0·5 per cent. of copper.

(2) New ends for second-hand tubes should be affixed by flash-butt welded process, adding a piece of unused new tube with its full normal thickness and unpitted surface. Stretching tubes is not recommended.

(3) Always place the new ends of second-hand tubes at the fire-box end, *i.e.*, thickest part of the tube to the greatest heat.

(4) Shot-blasting should be carried out on both inside and outside surfaces of boiler shell and fire-box, especially where cracking is feared.

(*b*) *Feed Waters.*—(1) Remember that per-

‖ Five papers worth referring to at this point are :—(1) Dorey, S. F., 1937, Trans. Inst. N. Architects, Vol. 79, page 50, "Note on the Chemical Intercrystalline Failure of Riveted Joints in Boilers"; (2) Calvert, A. P., 1939, *Journ.*, Am. Soc. N. Eng., Vol. 51, page 1, "Factors Influencing Failure of Naval Boiler Tubes"; (3) Hamer, P., and Stead, C. A., 1939–40, Trans. Inst. Mar. Eng., Vol. 51, page 167, "Modern Boiler Feed Water Treatments and Suggestions for their Application to Marine Boilers"; (4) Stewart, W. C., 1939, *Journ.*, Am. Soc. N. Eng., Vol. 51, page 348, "Some Observations Concerning Metal Cracking in Naval Boilers"; (5) Bedale, J. L., 1935, *Journ.*, Soc. Chemical Industry, Vol. 54, page 671, "Some Problems in Chemical Engineering which Arise in H.M. Navy."

¶ Hewson, G. W., 1941, *Journ.*, Soc. Chemical Industry, Vol. 60, page 764, "Water Treatment in Large Power Stations."

manent hardness in waters causes much more damage to boilers than temporary hardness.

(2) Treat feed waters externally, uniformly, and regularly, to give zero hardness if possible.

(3) Never use a water of known bad characteristics such as most mine, canal, and dock waters, if a good uniform bore or spring water can be obtained.

(*c*) *Method of Operation.*—(1) Add the feed near the surface of the water in the boiler, to allow escape of gases into the steam. If complete deaeration is impossible, add tannin or sodium sulphite.

(2) Fit a trough below the feed entrance pipe to aid the release of gases and to catch some of the sludge.

(3) Blow-down as continuously as possible, to avoid periodical excess concentrations of corrosive salts. Automatic continuous blow-down can easily be arranged to shut off when steam is not being used on locomotives.

(*d*) *Boiler Water Control.*—(1) Simplify and standardise boiler water control tests as much as possible, with the aid of representative boiler users, I.C.I., Ltd., and the British Standards Institution.

(2) Use boiler water control tests as part of the normal routine for all boilers.

(3) Maintain zero hardness and a definite alkalinity in the boiler water, paying attention to the possibilities of caustic embrittlement.

SUGGESTED OUTLINE FOR BRITISH STANDARD SPECIFICATION FOR BOILER WATER TESTS

(1) *Title.*—" Boiler Water Tests."

(2) *Contents.*

(3) *Co-operating Organisations.*—This should include :—

The Institution of Mechanical Engineers.
The Institution of Civil Engineers.
The Institution of Naval Architects.
The Admiralty.
Leading power house boiler engineers.
Railway companies.
Boiler insurance companies.
Lloyd's Register of Shipping.
The National Physical Laboratory.
Department of Scientific and Industrial Research Water Pollution Research Laboratory.
The Institution of Chemical Engineers.
Imperial Chemical Industries, Ltd.; Alfloc, Ltd.; and any other water treatment specialists, or their representatives, through the appropriate trade association.

(4) *Foreword.*—Boilers corrode, and tubes fail, through adverse water conditions far more frequently than through defects in the steel. Boiler water conditions are, moreover, capable of control.

The purpose of this specification is to focus attention to these facts, and to help engineers to obtain the maximum life from their boilers and boiler tubes.

So many different units have been used by chemists when referring to water constituents that comparison is greatly impaired. " Grains per gallon " may refer either to English or to American gallons. " Parts per 100,000 " or " parts per million " and molecular equivalents are all in everyday use. The universal adoption of " parts per 100,000 " has been suggested, but any action must wait on decisions by the British Standards Institution and on their being put into force by all the members of the various chemical institutions.

The universal adoption of this common language when speaking of water constituents, and the adoption of the standard tests outlined in this specification, should increase the safety of boiler operation over maximum periods between overhauls. It should minimise the wastage of steel tubes, plates, and other boiler components, and reduce to a minimum both losses in efficiency and engine lubrication troubles caused by wet steam. It should also aid the interchange of practical experience in terms common to all engineers in charge of boilers.

(5) *Definitions.*—The following facts regarding boiler water may have to be ascertained :—

Hardness : Temporary.
Permanent.
Total.
pH value.
Total dissolved solids.
Chlorides.
Suspended solids.
Alkalinity.
Sulphate ratio.
Oxygen content.
Oil content.

These facts may be required for water (*a*) as feed to the boiler, and (*b*) as samples taken from the boiler.

(6) *Apparatus and Chemicals Required for the Tests.*

(7) *Methods of Carrying out the Tests.*

(8) *Application of the Tests to Routine Boiler Control.*—(*a*) Stationary boilers working at pressures not exceeding 200 lb. per square inch ; (*b*) stationary boilers working at pressures exceeding 200 lb. per square inch ; (*c*) locomotive boilers ; (*d*) marine boilers working at pressures not exceeding 300 lb. per square inch ; (*e*) marine boilers working at pressures exceeding 200 lb. per square inch.

American Engineering News

Large Water Treatment Plant

While Chicago, with 1,500,000 population, has the vast reservoir of Lake Michigan as a source of water supply, the south end of the lake is subject to serious pollution, especially with sewage and industrial wastes from a group of manufacturing cities. As a result of this condition, the city has nearly completed a filtration and treatment plant having a capacity of 320 million gallons daily, and estimated to cost £5,400,000. This will serve only the southern section of the city, and eventually two somewhat similar plants will be required. Two special features are its construction as a pier or structure extending into the lake, and its use of a novel treatment by the sodium-silicate conditioning process. This process, developed in the experimental studies for the plant, serves to toughen or consolidate the coagulated matter, thus making it possible to use smaller settling basins and higher filtration rates, and consequently reducing the cost. Water is taken through shafts about 2 miles from shore, and pumped to a head of 18ft. above lake level, there flowing by gravity through the filtration and treatment works. Chemicals are to be added as the water flows through a channel equipped with agitators for rapid distribution, and then a channel so fitted with baffles as to ensure a uniform velocity of flow in the entire depth of the stream of water. The settling basins are of two-storey design. There are eighty filters of 1400 square feet area, with a depth of 13ft. 6in., and each having a capacity of 4,000,000 gallons daily. The gravel, graduated in sizes from $^1/_{12}$in. to 2½in., will be about 20in. thick, covered with 2ft. of sand. Chemicals will include alum, iron compounds, lime, ammonium sulphate, activated carbon, sodium silicate, sulphuric acid, and possibly sodium hexametaphosphate. In addition, the chlorination equipment includes fourteen chlorinators having maximum capacities of 300 lb. to 2500 lb. per twenty-four hours. Beyond the main pumping plant, the works are divided into three identical units.

Natural Gas Developments

While the natural gas industry of the United States is usually considered as an adjunct of the petroleum and manufactured gas industries, it is independent to a large extent, and its consumption includes commercial, industrial, and domestic uses. In 1941 this gas was produced in twenty-six of the States and consumed in thirty-five States, but nearly half of the wells are classed as oil producers. In 1941 pipe lines for natural gas totalled about 192,000 miles, of which 85,000 miles were main transmission lines and the remainder distribution lines. An increase of nearly 2000 miles was due to increase in fuel demands of plants working on war material. Besides its use as a primary fuel for boilers, furnaces, and internal combustion engines, and for heating buildings, it serves as a processing agent in precise heat control for heat treatment of metals and in the manufacture of plastics, ceramics, glass, foods, and other processed products. Furthermore, as a new source of raw material it provides essential ingredients in the manufacture of synthetic rubber, high-octane motor fuels, paint and varnish solvents, and hydrogenated fats for cooking compounds. Its industrial use has great possibilities, as in present experiments with low-temperature reduction of lean iron ores from four vast deposits never yet commercially exploited on account of economic restrictions. Owing to its wide distribution, natural gas has particular advantages under the present tendency to the decentralising of industry, since plants can be located in areas where ample supply of gas is assured. This tendency applies specially to plants manufacturing war materials of various kinds, many of these new plants being established in open country, far removed from centres of industry. One notable use of this gas is in the manufacture of carbon black. Its value at points of consumption in 1941 reached £133,000,000.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

PHOSPHOR-BRONZE AND LEADED BRONZE ELECTRICAL PROTECTIVE RELAYS

No. 142. This revision represents a complete redraft of the 1927 issue, which has become out of date, owing to the advance in the art. Provisions for many new types of relay have been included, such as distance relays, open and reverse phase-sequence relays. An attempt has been made to subdivide the so-called instantaneous relays into classes according to their speed of operation. The requirement as regards the capacity of relays to withstand sudden overloads has been extended. The range of settings which may be regarded as normal are given for each type. A recommended characteristic curve connecting time and current for relays having an inverse time lag with a definite minimum has been introduced for the first time as an appendix. Thus, while at the present time this is not an obligatory feature, it is hoped, when new relays are designed, that the recommended characteristic curve should always be adopted.

WROUGHT STEELS

No. 970. This specification is a revised issue of B.S. 970 for Wrought Steels, which was originally issued in July, 1941. It is composed of a series of fifty-eight specifications for wrought and alloy steels, known as the " En Series," which, it is considered, are adequate to cover all the general engineering requirements of industry during the war emergency. This attempted rationalisation of the steel industry was, in the early part of 1942, taken a step further, and a " direction " was issued by the Iron and Steel Control stating that for general engineering purposes all steels must comply with a reduced range of forty-four steels selected from B.S. 970. When B.S. 970 was first issued it was realised that an early review might be necessary as a result of experience gained in working to the " En Series." The revision has now been completed and the principal modifications are listed below :—(i) Six additional specifications, which are subdivisions of existing steels, have been included for special purposes. (ii) In one or two cases typical chemical compositions within close limits have been provided as alternatives to the present specifications. In such cases requirements for the mechanical properties have not been included. (iii) Minor adjustments have been made to some of the figures for chemical composition and mechanical properties. Price 5s. 5d. post free.

ADHESIVE INSULATING TAPE

No. 1078. This war emergency specification deals with adhesive tape, commonly known as black sticky tape, as used in the electrical trade. Various Government Departments and other large purchasers have in the past had their own specifications for this class of material, and the problem of the moment is to produce a tape using the minimum amount of raw rubber without unduly lowering the quality of the tape. The specification is intended to replace all the existing departmental and other specifications, and the tests incorporated are designed to ensure as high a quality as is possible consistent with the present circumstances as regards rubber supplies. Price 1s. (1s. 3d. post free).

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer

Iron and Steel in the United States

The enormous war demand for iron and steel in the United States is affecting all departments. Whilst there have been instances of late deliveries and of consuming works being held up as a result, in general the methods of the American authorities in distributing the steel have resulted in smooth working. Production of pig iron and steel has been and is being considerably increased. On the Pacific Coast the production of pig iron will be increased with the starting in December of a new blast-furnace at the Provo Works of the Colombia Steel Works, a subsidiary of the United States Steel Corporation. The new furnace has been reconstructed with materials and equipment from a furnace in the Chicago district, which was dismantled and shipped to the new site. In April another blast-furnace will commence operations at Geneva, near Provo. This will make four active blast-furnaces on the Pacific Coast west of Pueblo, Colorado. Two new furnaces are also in operation at Youngstown and are producing at capacity. The scrap position has become somewhat easier as a result of the nation-wide salvage drive. The relief to the steel works, however, has not been so noticeable because so much of the scrap included household junk, which needs sorting and preparation by scrap yards before it can be used by the steel furnaces. The accumulation from the collections reaches 560,000 tons, but the tonnage the steel works want for their winter stock piles has been placed at 4 to 7 million tons. The production of steel has increased to an average of 100·2 per cent. of steel ingot capacity, equal to 1,714,100 tons of ingots weekly. At Pittsburgh the output exceeds 100 per cent., following repairs to the steel furnaces. The new Geneva Steel Company, Utah, is expected to commence making steel in May, 1943, and the structural mill, slab mill, and plate mill will start in May and June. Deliveries of finished steel by subsidiaries of the United States Steel Corporation for September reached 1,703,570 tons. This is the highest figure for any September record, but is below the August total of 1,788,656 tons. Operations at the tinplate mills have fallen to 25 per cent. This is partly due to Government restrictions on the use of tinplate.

The Pig Iron Market

It is possible that the campaign in Northern Africa will have an important influence on the British iron and steel industry. Although the industry has been able, by skilful adaptation, to maintain supplies to all the essential war industries, it is no secret that supplies of certain ores have barely met the requirements of the industry. In the case of hematite ore, there has been a shortage which has resulted in tight conditions in supplies of hematite pig iron, as a result of the somewhat scanty imports of the high-grade ore needed for the manufacture of this description of pig iron. The home sources of iron ore have been greatly expanded, and the blast-furnace industry has been obliged to restrict the quantities of foreign ore they normally used in their mixtures. The prospect of opening the western ports of the Mediterranean to British shipping has given rise to hopes that in the not-distant future supplies of iron ore will be obtained from Algeria, and this will be a development which will afford considerable relief to the British pig iron industry. The stringent conditions which have ruled in the hematite department otherwise show no indication of becoming easier, and the Control continues to exercise great caution in distributing supplies. It is only in cases in which hematite is required for essential work and for which no other description will serve that parcels are released. Consumers by this time have become accustomed to making do with substitute pig irons, and in view of the fact that not very long ago they were unfamiliar with the material they now have to use, they have succeeded beyond expectations. The big demand for heavy castings, which comes principally from the engineering industry, has resulted in an urgent call for low-phosphoric and refined pig irons. So far as the refined descriptions are concerned, consumers engaged upon war work are getting their requirements and do not have to wait long for supplies. The position is certainly more difficult than it was a few months ago. There are indications also that low-phosphoric irons are becoming tighter, and the Control is carefully watching over the distribution of these qualities. A satisfactory point, however, is that owing to the care the Control has exercised over the distribution of pig iron supplies there seems no likelihood of the war effort being handicapped. There is no stringency in supplies of high-phosphoric pig iron, although the demand for this description has been more active during recent weeks. The production of basic pig iron also is sufficient to meet the heavy demands of the steel makers.

The Midlands and South Wales

The Midland steel works are operating under extreme pressure, but although the demand has grown since the opening of the quarter, the industry by great efforts is meeting the full requirements of the firms employed upon war work. The munitions and armaments manufacturers are continually pressing for larger supplies of steel, including considerable quantities of alloy and special steels. The demand for the latter description is urgent, and all available plant has been pressed into service, but, even so, production is barely sufficient to meet the needs of the consuming industries. There is an insistent request for cold-rolled strip and bright-drawn steel, which seems to be expanding as time goes on. The recent improvement in the position of constructional engineers in most districts has created an active demand for sections, although the volume of business in heavy joists does not seem to have increased so much as might have been expected. The pressure from consumers to obtain steel plates of practically all sizes and thicknesses is unrelaxed. The shipbuilding industry is probably taking the largest tonnages, but tank makers are also using large quantities, and there is a strong demand for boiler plates from the locomotive makers. The producing works are meeting the demand on the whole satisfactorily, but some works have sufficient orders in hand to keep them fully employed until the end of June, 1943. The sheet works are busy, and their orders include a number from the Government for special grades. In South Wales the pressure of demand for all descriptions of steel is taxing the resources of the works. Considerable quantities of structural steel have been produced, and the demand seems to be gradually expanding. The tinplate industry is not well employed, and business in substitutes does not seem to be making much headway. The export business in tinplates, owing to Government restrictions, is negligible. There is a large production of sheet and tinplate bars which absorbs the steel allotted to the manufacturers, and good supplies of billets are being sent from Welsh works to other parts of the country. There has been no abatement in the demand for plates and there is a tendency for delivery dates to lengthen.

Scotland and the North

The Scottish iron and steel makers have been struggling for some time to keep abreast of deliveries and have achieved considerable success in this direction. The features of the market have not changed much during recent weeks, and the demand for plates is still one of the outstanding features. These are required in heavy quantities by the shipyards and tank makers. Locomotive builders have also taken up good tonnages, whilst it is thought that an expansion in locomotive building will result in a considerable increase in the pressure to obtain boiler plates. In spite of the efforts which have been made to increase the production of alloy steel, the large requirements of the armaments, munitions, and aircraft manufacturers have kept the demand practically at the level of output. It will probably be learnt one day that the increase in the production of alloy and special steel has been one of the outstanding industrial achievements of the war. But, even so, the production is barely sufficient to meet the demand. The engineering industry, which is fully employed upon war work, is also taking up all the special steel obtainable. The constructional engineering firms are well employed, and the position in this respect is in strong contrast to that ruling a month or two ago. Their requirements are keeping the steel makers busy in producing joists and sections, whilst they are also taking up good quantities of light plates and sheets. The re-rolling industry is actively employed and there is a tendency for the demand for small steel bars and sections to increase. A large volume of business has been transacted lately in semis with Lancashire consumers, and there has been a sharp increase in the request for acid forging billets. The wire makers have been consistently busy for months, and are afforded an important outlet for wire bars. The demand in this district for structural steel has improved, but business in joists has not increased to the extent expected. There has been no decline in the demand for steel bars, and both heavy and small sizes are passing into consumption in considerable volume.

The North-East Coast and Yorkshire

The demand for practically all descriptions of finished steel is increasing, and although all available plant on the North-East Coast is in production, the output barely meets consumers' requirements. The production of steel ingots has been stepped up, but the demand appears to have increased in proportion, and the requirements o the rolling mills are not easily met. The call for semi-finished steel in the shape of billets and sheet bars is insistent, and although consumers are obtaining their requirements, it is only as a result of great efforts by the steel makers. The production of semis in Great Britain is on a heavy scale, but, even so, it is necessary to draw upon the stocks of imported materials. It was stated some time ago that imports of this material would be on a greatly reduced scale, but recently it is understood that larger quantities than were anticipated have reached this country. The pressure to obtain deliveries of plates is unrelaxed, and large quantities are going to the shipyards, where there is a heavy programme of construction in hand. The tank makers and locomotive builders are also important users of plates, whilst recently the demands of constructional engineers for light plates have been noticeable. Constructional engineers are also taking up big tonnages of sections and their requirements of light sections are keeping the re-rolling works busy. The sheet makers are in a satisfactory position as regards orders, and have enough work in hand to keep them fully employed into the New Year. The position in the Yorkshire steel industry is unchanged and the producers are continually struggling to meet the heavy demand which is noticeable in all departments of the industry. There is a tendency for deliveries to lengthen, but the Iron and Steel Control is watching the position and would probably take steps to check any serious movement in this direction. The raw materials position is satisfactory, and the works have no grouse on this score. The output of acid carbon steel is maintained at a high level, but the demand also appears to be increasing. The call for alloy and special steels, which has been a feature of the market for so long, is undiminished, and there is a strong request for high-speed steel and for "substitute" grades. There is a stringency in supplies of high-tungsten steel.

Iron and Steel Scrap

The new wagon labelling scheme which has been in operation for a few weeks appears to have passed through its most troublesome stage and to be working smoothly. The general view is that it has enabled regular supplies to be maintained to consumers. In other directions there is not much change in the position. Generally speaking, the demand is well maintained, but it is chiefly for the heavier and better qualities, and the lighter descriptions of scrap which are in abundant supply are not so easily disposed of; in fact, at a number of points considerable quantities have accumulated. Good heavy steel scrap cut to furnace sizes at 69s. 3d. and 72s. 6d. is in rather short supply, and consumers are taking up the parcels offered them. There are also large quantities available of old light wrought iron and steel, but consumers show little interest in this description, and little business is passing. There is an active demand, however, for hydraulically compressed steel shearings at 69s. 3d. to 72s. 6d., and bundled steel scrap at 64s. and 67s. 3d., and sellers have little difficulty in disposing of their material. On the other hand, the volume of business passing in mild steel turnings is comparatively small, and stocks of most grades in merchants' hands appear to be plentiful. Mixed wrought iron and steel scrap for basic steel furnaces are meeting with a rather better demand than of late. Good heavy material is quoted at 67s. 3d. and 72s. 6d. The light material at 49s. 6d. to 53s. 3d. is not meeting with a strong demand, and large quantities are being freely offered. Consumers are taking up good deliveries of compressed basic bundles at 66s. to 69s. 3d., and there are indications that the demand for this description is slowly expanding. Generally speaking, ironfounders do not find it difficult to cover their needs, but heavy machinery cast iron scrap is rather difficult to obtain in some districts. Light cast iron scrap is quoted at 71s. 6d. to 74s. 9d., and the demand for this description has become more active of late. Acid carbon steel scrap is easily disposed of at 90s. 3d. for the 0·04 per cent. maximum sulphur and phosphorus content and 81s. 3d. for 0·05 per cent.

ROUMANIA TO EXTEND ELECTRIFICATION.—The State Railways of Roumania are being mentioned as interested in the completion of a power station, which is to be built at the Iron Gates pass on the River Danube. The new power station is intended to be the largest of its kind in Europe and to produce 3,000,000 kW an hour. It is being designed to supply current to the whole of Southern Roumania, Northern Bulgaria, and some districts of Serbia.

Notes and Memoranda

Rail and Road

THE FILTRATION OF PRODUCER GAS.—The Government has approved the incorporation in emergency producer gas plant of a new type of filter based on the design developed by the British Coal Utilisation Research Association and I.C.I., Ltd. If the new system disposes of the outstanding difficulty of efficient gas filtration, both from the point of view of removal of harmful material from the producer gas and simplified means for maintaining the filter in good condition, it is held that a great technical advance will have been made.

GERMANY RAIDS THE BELGIAN RAILWAYS.—The latest available figures bring Germany's theft of Belgian transport materials up to 1000 railway locomotives, 16,000 wagons, and 625 miles of rails. The rails came from shunting sidings and branch tracks in various areas. In a single day twenty-eight wagon loads of second-hand rails were dispatched to Germany. The Germans have also demanded from the French National Railways about 7800 miles of rails for the repair of bombed track, but these demands have not been met in full.

NEW HIGHWAYS FOR BULGARIA.—Germany is pushing its policy of constructing new roads in countries occupied by her troops. In Bulgaria, the German concern known as the Todt Organisation is too busy elsewhere to do the work, but it has secured the right to sub-contract the work. Offers of private road concerns having proved too high, the task as a whole is to be left to a new German concern named Biost, founded jointly by the Hermann Göring Works and certain German road firms. This concern is to execute the road programme at what is described as a "reasonable" price.

Air and Water

A GIFT FROM RAILWAYMEN.—The workmen of the New York Central Railway have presented a Martin B-26 twin-engined bomber to the Army Air Forces. Mr. F. E. Williamson, president of the New York Central System, explained that 138,000 employees had subscribed 170,000 dollars for its purchase.

SOUTH AFRICAN AIRWAYS.—A note in *The Aeroplane* states that South African Airways is understood to be operating a service between Lourenço Marques (Portuguese East Africa) and the Witwatersrand to connect with the flying boat port of call at Vaalbank Dam, near Vereeniging. In addition, the company operates between Cape Town and Leopoldville. Lockheed "Lodestars" are in use on both routes.

NEW RECORD FOR BRIDGE SPAN.—There has just been opened in America a bridge crossing the Connecticut River at Hartford, Conn., part of a scheme embodying a by-pass which is expected to reduce by 25 per cent. the load of 80,000 vehicles per day on an old stone arch bridge. The new bridge is 3950ft. long, with the main river crossing consisting of an 840ft. girder continuous over three spans of 270ft., 300ft., and 270ft., the 300ft. centre span being the longest in the United States.

POST-WAR ROUMANIAN PLANNING.—The Minister of Public Works in Roumania is said to be at work on a project for the post-war construction of inland waterways which will provide a means of communication between Bucharest and the Danube, and thence to the Black Sea. If the scheme matures, this waterway would shorten the existing rail communications by some 156 miles, and would be navigable for vessels of up to 1000 tons. The total cost of the scheme would be high, and from seven to eight years would be required to complete it.

CEMENT LINING FOR CAST IRON WATER PIPE.—The City Council of Waterbury, Conn., U.S.A., had a 2-mile main more than ten years ago, but never used it. Now these pipes are needed for an extension, and they are to be cleaned and lined with cement mortar. They are 36in. and 42in. diameter. Cleaning and lining operations, performed with a centrifugal machine of special design, have been carried out at the rate of 1000ft. a day. A special type of apparatus had to be developed which travels along the inside of the pipe. The centrifugal force created by the rapidly revolving shaft causes the steel casting to rub against the inside surface of the pipe, creating an abrasive action, which effectively removes all paint and foreign matter from the interior surface. This action also roughens the interior of the pipe, thus providing a surface for the bond between the cast iron and the cement mortar to be applied later. A blower is set up outside the pipe for the purpose of forcing a continuous draught of air through the pipe to carry paint fumes and dust particles away from the operator.

Miscellanea

INSTRUMENT JEWELS.—The General Electric Company of America is manufacturing synthetic jewels to replace imported sapphire jewels, the supply of which has been cut off by the war. Engineers say there is little to choose between the new jewel and sapphire for miniature instrument application.

WOMEN AS BOILERMAKERS.—For the first time in the sixty-two years since the founding of the U.S. International Brotherhood of Boilermakers, women are being admitted to membership. The Council's action was taken to comply with requests of the Government to solve the problem created by the employment of women in shipyards and other war projects.

THE LATE MR. J. PALIN.—We regret to learn of the death, on November 16th, of Mr. J. Palin, founder and chief of the Dalyte Electrical Company, North Kensington. Mr. Palin was widely recognised as an authority on the design of special electrical gear for materials handling plant, having pioneered the equipping of some of the largest coal and iron ore handling installations in this country and abroad.

COPPER FROM CHILE.—The output of copper in Chile during 1941 was 453,594 metric tons, and established a new record, the total being 40,000 tons more than the previous record in 1937 and 116,000 tons more than the output in 1940. The United States took about 90 per cent. of Chile's copper exports, but since February, 1942, the whole of the country's output has been acquired by the U.S. Government.

PETROLEUM IN WARTIME.—The output of petroleum in Argentina during the first six months of 1942 has risen by nearly 9 per cent. over the figure for the corresponding period of 1941. The total was 1,843,000 cubic litres. The search for fresh sources of supplies goes on apace and efforts are being intensified in several of the Canadian Provinces to extend the proved areas where oil is now being produced. Various structures in Alberta, which had been abandoned after earlier drilling found gas, but not oil, are being re-examined.

CONTROL OF WIPING RAGS.—An Order of some importance to engineers is the Control of Rags (No. 1) (Wiping Rags) Order, 1942, made by the Minister of Supply, and effective from October 26th. It fixes maximum prices for the sale of wiping rags and defines a wiping rag as "any worn out, disused, discarded, or waste fabric or material made wholly or mainly of wool, cotton, silk, rayon or flax, or any mixture of these fibres, which is not less than 144 square inches in size and has been trimmed, washed, or sterilised, and is suitable for use as a wiping rag."

PLASTICS AND LEATHER.—The experts of the Leather Industries Research Institute of South Africa have developed a new plastic, which, when it is dissolved in a suitable solvent, produces a material which has the property of binding and firming fibrous materials, such as leather or felt. It has been widely used for stiffening the insoles of Army boots, the purpose for which it was originally developed. At first this plastic was made at the Institute, but demands became so great that arrangements were made for large-scale production at Port Elizabeth.

MAGNESIUM BY THE PIDGEON PROCESS.—The production of magnesium promises to be increased by a new ferro-silicon process developed by Mr. L. M. Pidgeon, of the Canadian National Research Council. He found that the reaction between ferro-silicon and magnesium oxide proceeds smoothly at practicable temperatures under vacuum in the presence of calcium oxide. Metallic magnesium distils readily at the reaction temperature and condenses in great purity as a crystalline lining in a condenser tube connected with the reaction retort. We learn that the process is being worked by the Ford Motor Company "somewhere in Michigan."

CANADIAN ELECTRIC POWER OUTPUT.—This year electric power output in Canada has risen by more than 17 per cent. above a corresponding period in 1941. Large additions to hydro-electric installations are under construction, yet even these, it is stated, will not meet the total demand. Consequently, all forms of non-essential use of power are being curtailed in the principal centres of war industry. These restrictions have already radically changed the appearance of Canadian towns and cities. Only sufficient lighting for public safety is allowed and all advertising and display use of power has been cut out. This will mean a saving of 160,000 H.P., while an additional 100,000 H.P. to 140,000 H.P. will be required to meet demand this winter.

Personal and Business

MR. G. W. PALFERMAN has been appointed secretary of J. Samuel White and Co., Ltd.

MR. J. R. PHEAZEY has been appointed works director of Standard Telephones and Cables, Ltd.

SIR WILLIAM CROSTHWAITE has been elected Chairman of the Tees Conservancy Commission.

MR. J. A. NORTHFIELD, M.I. Mech. E., has been appointed technical manager of the Key Engineering Company, Ltd., 4, Queen Victoria Street, E.C.4.

MR. W. S. ATKINSON, formerly works manager of the Stockton Forge Works of Head, Wrightson and Co., Ltd., and now local representative, has been presented with an inscribed wallet containing savings certificates by the chairman of the company, Sir Guy Wrightson, Bart., on completion of sixty years' service with the firm.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE *at which the meeting is to be held should be clearly stated.*

Association of Scientific Workers

Saturday and Sunday, Dec. 5th and 6th.—Gas Industry House, 1, Grosvenor Place, S.W.1. "Scientists of the United Nations and the War Effort." 2.30 p.m. (Saturday) and 11 a.m. (Sunday).

Bradford Engineering Society

Monday, Dec. 14th.—Technical College, Bradford. "The Shorter Flame Hardening Process," Bramhill. 7.15 p.m.

British Association of Refrigeration

Thursday, Dec. 10th.—Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. "Anglo-American Relations, with Some Observations on the Refrigerating Industry," C. B. Morrison. 3 p.m.

Institute of Economic Engineering

Sunday, Dec. 13th.—Waldorf Hotel, Aldwych, W.C.2. "Engineers' Brains Trust." 2.30 p.m.

Institute of Fuel

Thursday, Dec. 10th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. "Fuel Economy at Collieries," H. E. Partridge. 2.30 p.m.

Institution of Automobile Engineers

Sunday, Dec. 13th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "The Possibilities of Motorcycle Engineering," Graham Walker. 2.30 p.m.

Institution of Civil Engineers

Saturday, Dec. 5th.—YORKSHIRE ASSOC.: Hotel Metropole, Leeds. "Mining Subsidence," Professor D. Hay. 2.30 p.m.

Institution of Electrical Engineers

Saturday, Dec. 5th.—N. MIDLAND STUDENTS: Griffin Hotel, Boar Lane, Leeds. Chairman's Address. "The Manufacture and Installation of Air Space, Paper Core, Telephone Cables," R. J. Griffiths. 2.30 p.m.

Monday, Dec. 7th.—LONDON STUDENTS: Savoy Place, Victoria Embankment, W.C.2. "The Failure of the Technician in His *Rôle* as Citizen," D. S. Anderson. 7 p.m.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham. "Fluorescent Lamps," L. F. Davies, R. H. Ruff, and W. J. Scott. 6 p.m.

Wednesday, Dec. 9th.—TRANSMISSION SECTION: Savoy Place, Victoria Embankment, W.C.2. "Some Problems in Transmission Line Design," A. Burke. 5.30 p.m.

Institution of Mechanical Engineers

Friday, Dec. 18th.—Storey's Gate, Westminster, S.W.1. "The First Gas Turbine Locomotive," Dr. A. Meyer; "A New Rotary Compressor," A. J. R. Lysholm. 5.30 p.m.

Institution of Production Engineers

Saturday, Dec. 5th.—SHEFFIELD SECTION: Royal Victoria Hotel, Sheffield. "Substitute Steels," Dr. W. H. Hatfield. 2.30 p.m.

Iron and Steel Institute

Thursday, Dec. 10th.—SHEFFIELD SECTION: Royal Victoria Station Hotel, Sheffield. Autumn meeting. 2.30 p.m.

Junior Institution of Engineers

Saturday, Dec. 12th.—39, Victoria Street, S.W.1. Presidential Address. "Gas: Its Place in the National Fuel Economy," Sir David Milne Watson. 2.30 p.m.

Manchester Geological and Mining Society

Tuesday, Dec. 8th.—Queen's Chambers, John Dalton Street, Manchester. Ordinary meeting. 2.45 p.m.

Newcomen Society

Wednesday, Dec. 9th.—James Watt Memorial Institute, Great Charles Street, Birmingham. "Ancient Tools in Herefordshire," F. C. Morgan; "A Note on Some Boulton and Watt Workshop Tools," W. K. V. Gale. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Dec. 11th.—Mining Institute, Newcastle-upon-Tyne. "The Electrical Equipment of Shipyards," H. M. Coatsworth.

Printing.—George Reveirs, Ltd., 10-12, Rosebery Avenue, E.C.1, are PREPARED to SUBMIT ESTIMATES for all DESCRIPTIONS of PRINTING. "THE ENGINEER" has been printed at this establishment since its commencement.

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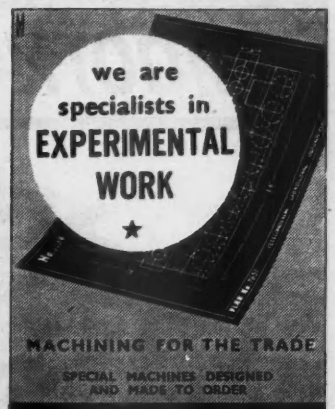

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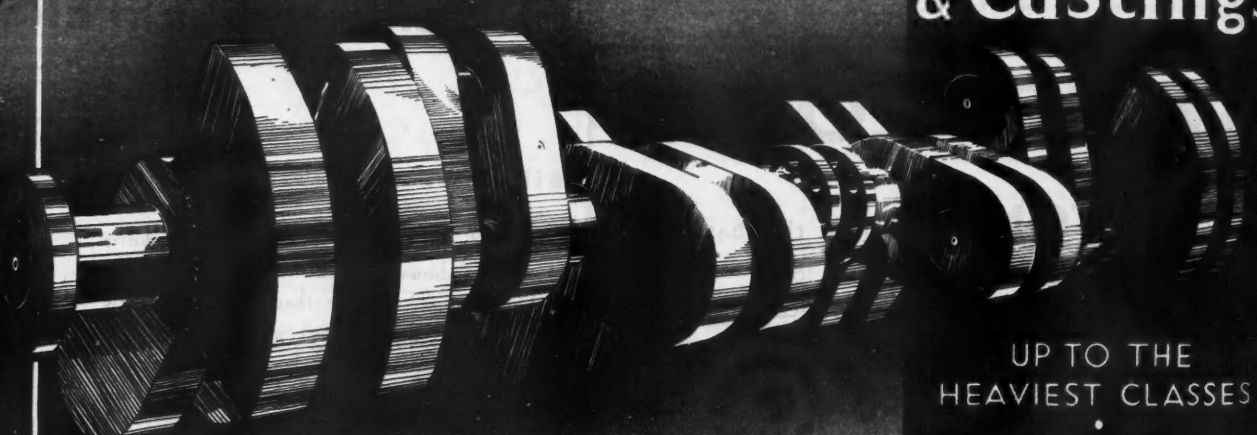

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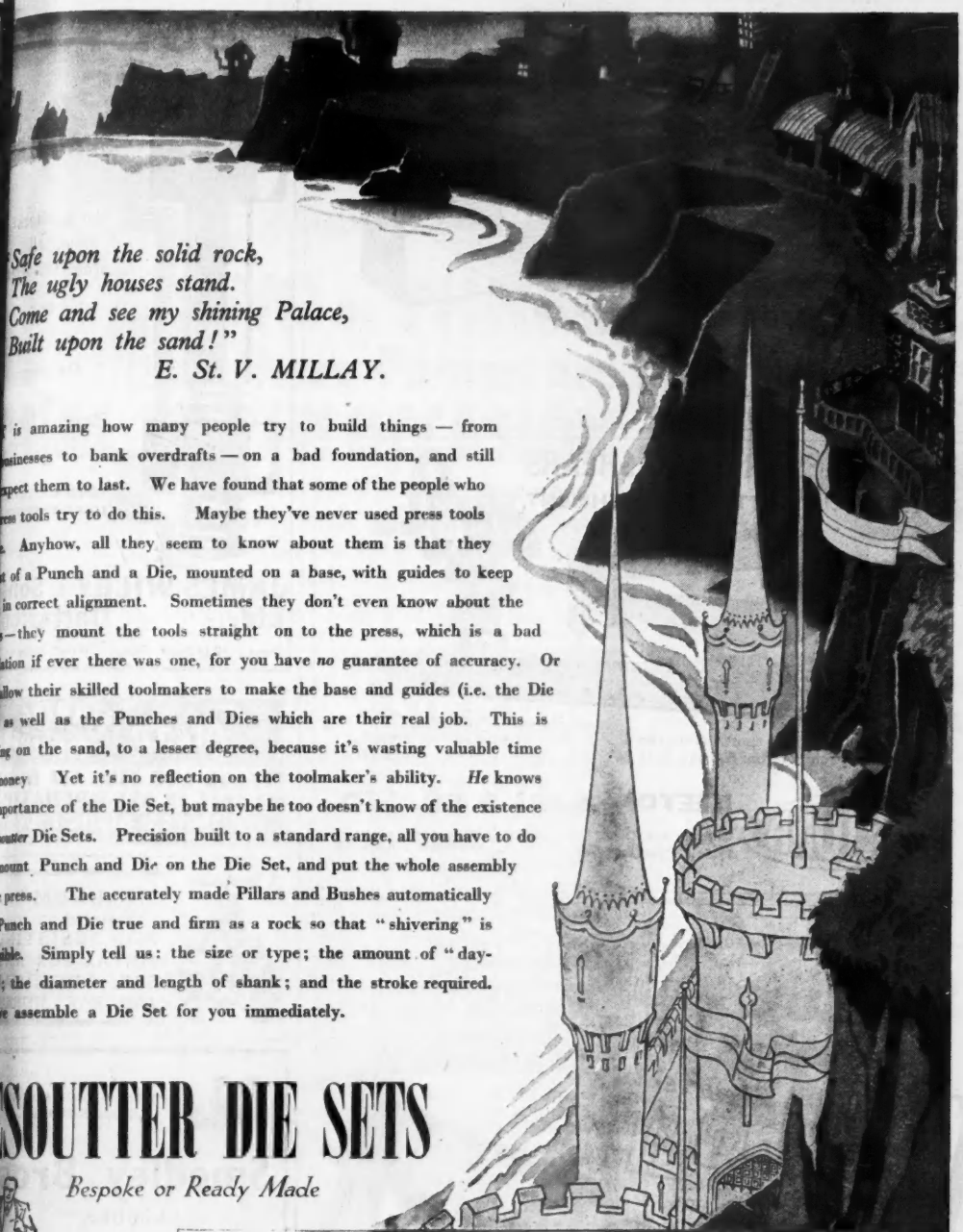

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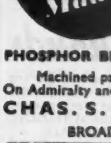
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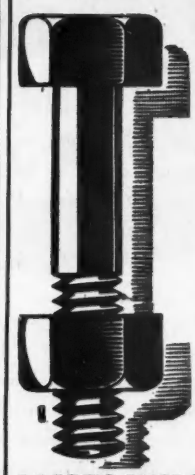

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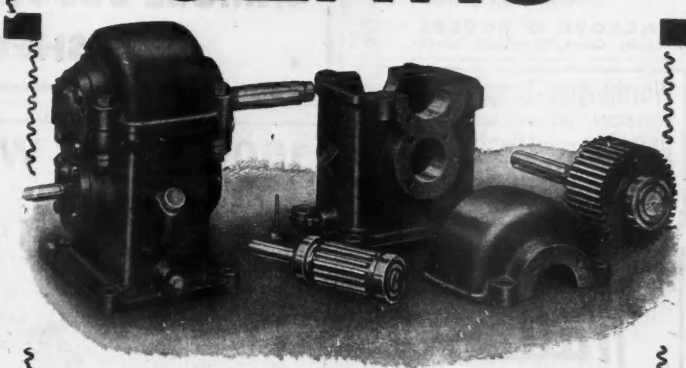

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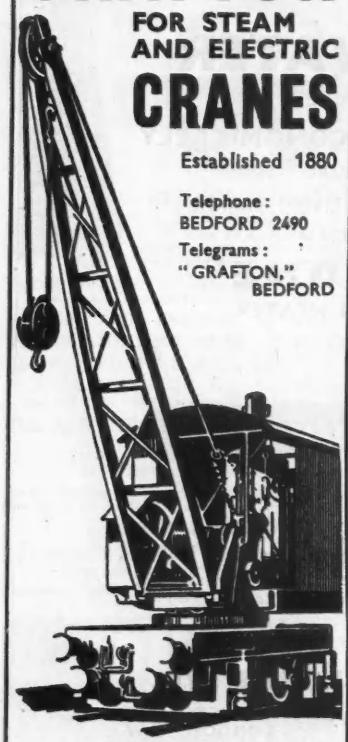

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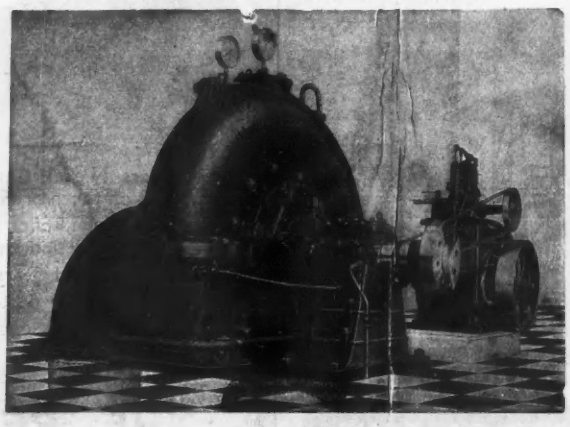

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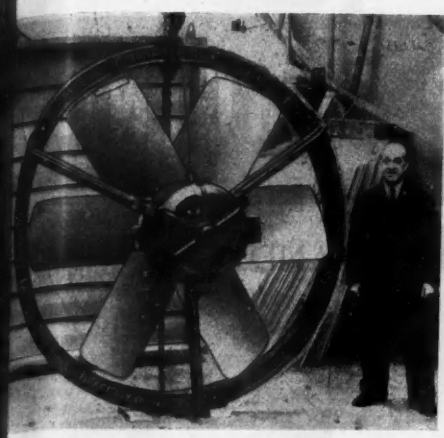

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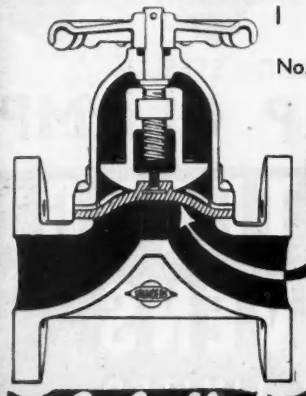

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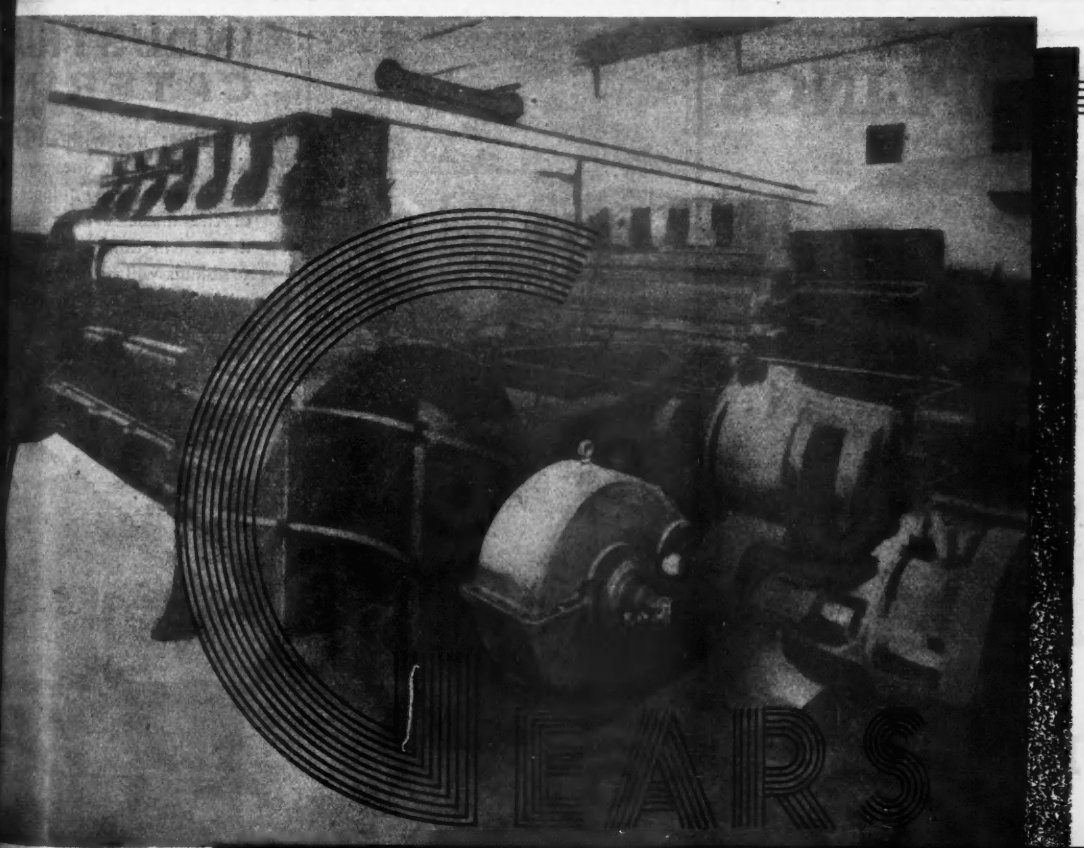

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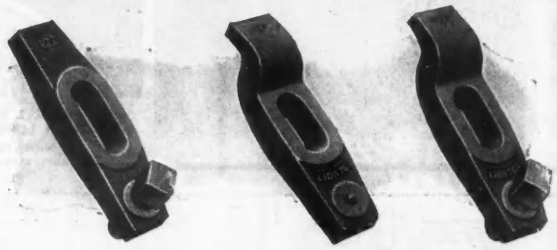

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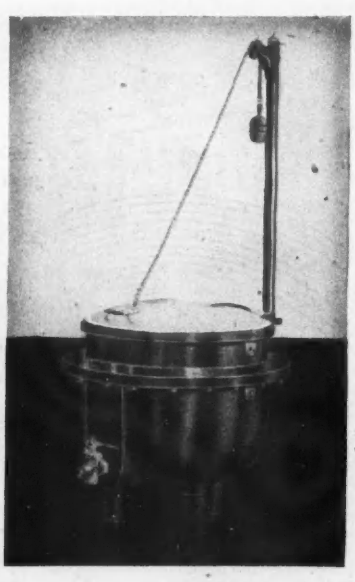

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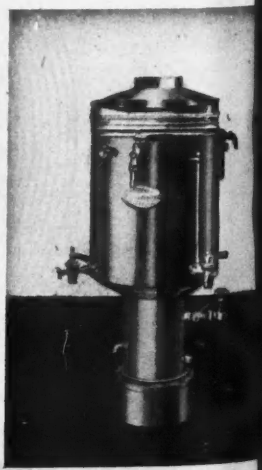

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